NATURAL HISTORY OCCASIONAL PAPER NO. 12

Natural History of the Andrew Lake Region, Northeastern Alberta

Edited by
W.B. McGillivray
R.I. Hastings

Provincial Museum of Alberta

Alberta
CULTURE AND MULTICULTURALISM

Natural History of the Andrew Lake Region, Northeastern Alberta

Errata (corrections in *italics*)

1. Wallace and Wershler (1983) should read as *Wallis* and Wershler (*1984*) throughout.
2. Page 2, column 1 - Moss (1983) should read as *Packer* (1983).
3. Page 15, column 2 - Bird (1968) should read as Bird (1968*a*).
4. Page 15, column 2 - Vitt and Andrus should read as Vitt and Andrus (*1977*).
5. Page 19, column 2 - heading should read as Phytogeography of the *Andrew* Lake Flora.
6. Page 20, column 1 - Strong and Leggat (1983) should read as Strong and Leggat (*1981*).
7. Page 22 - add the following references:

   Cody, W.J. 1956. New plant records for northern Alberta and southern Mackenzie District. Canadian Field-Naturalist 70:101-130.

   Fairbarns, M. 1983. Cameron Hills biophysical survey. Natural Areas Technical Report No. 9. Alberta Energy and Natural Resources, Edmonton, Alberta.

   Lee, P.G., R.A. Ellis and P.L. Achuff. 1982. Vegetation and flora of the Caribou Mountains, Alberta. Canadian Field-Naturalist 96:389-408.

   Packer, J.G. and C.E. Bradley. 1984. A checklist of the rare vascular plants in Alberta. Natural History Occasional Paper No. 5. Provincial Museum of Alberta, Edmonton.
9. Page 22, column 2 - Jansens, J.A. should read as *Janssens*, J.A.
10. Page 90, column 1 - Great-nested flycatcher should read as Great-*crested Flycatcher*.
11. Page 91 - add the following references:

    Wallis, C. and C. Wershler. 1984. Kazan Upland resource assessment for EcologicalReserves Planning in Alberta. Natural Areas Technical Report No. 12. Alberta Energy and Natural Resources, Edmonton, Alberta.

    Williams, M.Y. 1922. Biological notes along fourteen hundred miles of the Mackenzie River system. Canadian Field-Naturalist 36:61-66.

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NATURAL HISTORY OF THE ANDREW LAKE REGION, NORTHEASTERN ALBERTA

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CONTENTS

Foreword iv

Environment, vegetation, and flora of the Andrew Lake area, northeastern Alberta
ROSS I. HASTINGS AND ROBERT A. ELLIS 1

Aculeate wasps (Hymenoptera) [with the exception of the Formicidae] of Andrew Lake
ALBERT T. FINNAMORE 33

Ground beetle (Coleoptera: Cicindelidae and Carabidae) habitat selection at Andrew Lake, Alberta
DANNY SHPELEY 47

Annotated list of the butterflies (Lepidoptera) of Andrew Lake
TERRY THORMIN 63

The fish and herpetofauna of Andrew Lake
MARK STEINHILBER 65

Birds of the Andrew Lake Region
GARY ERICKSON AND W. BRUCE McGILLIVRAY 83

Mammals at Andrew Lake, Alberta
HUGH C. SMITH 93

FOREWORD

Staff and associates* from the Provincial Museum of Alberta camped on the shore of Andrew Lake in northeastern Alberta from 10-19 June 1988. Researchers representing the Ornithology, Mammalogy, Botany, Ichthyology, and Entomology programs collected specimens and recorded observations to document the natural history of this little-studied region. This volume, the compilation of their efforts, represents a companion to Occasional Paper No. 10: The Natural History of the Bistcho Lake region, Northwest Alberta published in 1988.

Expeditions of this type were the means used to build the natural history collections in all the major museums in North America. In the last 30 years, museum research has become increasingly specialized and project oriented. Collection building was assumed to be complete. The results of our expedition published here and of our previous trip to Bistcho Lake demonstrate the need for traditional collecting. The documentation of species distributions and habitat requirements is clearly critical to our ability to understand and conserve the diversity of Alberta.

I would like to acknowledge Glen Wetlauffer and his staff at Andrew Lake Lodge for their assistance in the field. The work of Colleen Steinhilber, Donna Reilly, Steve Fisher, Carolyn Lilgert and Frank Geddes in typing and designing the volume is greatly appreciated.

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ENVIRONMENT, VEGETATION, AND FLORA OF THE ANDREW LAKE AREA, NORTHEASTERN ALBERTA

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INTRODUCTION

Andrew Lake is located in the far northeast corner of Alberta, about 3 km from the Northwest Territories and Saskatchewan borders. It lies on the rugged Kazan Upland of the Canadian shield and is surrounded by extensive muskegs. Their are no roads and access to the lake is limited to air. Despite its remote and rugged nature, the surrounding Kazan Upland has a long history of biologic and geologic exploration. This is attributable to: (1) the fur trade in the Lake Athabasca area, (2) the search for the Franklin expedition, and (3) the mineral wealth of the Canadian Shield.

The area between Lake Athabasca and Great Slave Lake was explored by Raup (1935, 1936, 1946) and Moss (1953a,b). Their investigations were principally in the lowland areas between the lakes and neither group appears to have investigated the shield country around Andrew Lake. This is not surprising as Andrew Lake, unlike many lakes in the region, has no direct river connection to the Mackenzie drainage system. All portages to the lake would be long and over very rugged country. Raup notes in his 1946 paper that he could not investigate large areas of the country and that air travel for biological purposes was unavailable when he did his surveys in the 1930s.

Wallace and Wershler (1983) did a general biological reconnaissance survey of part of the Kazan Upland for the Natural Areas Program. They investigated Wylie and Colin Lakes, which are about 25 km south of Andrew Lake. An extensive survey of the Lockhart River map area in the adjacent Northwest Territories has been done by Bradley et al. (1982).

Soil and surficial geology surveys of the Kazan Upland of Alberta generally and the Andrew Lake area specifically have been conducted by Godfrey (1961, 1963). These surveys included a network of ground surveys and rock sampling in addition to air photo interpretation. Geologic maps are included in all these reports.

Our primary objectives in this investigation were to describe the vegetation, collect the vascular and non-vascular flora, and develop a checklist of these species for the Andrew Lake area. Secondarily, we attempted to gain insight into the area's fire history and describe its soils. Some comparisons of flora and soils were made with our 1987 work at Bistcho Lake, which lies in the Boreal Subarctic ecoregion of northwestern Alberta (Hastings and Ellis 1988a).

METHODS

Forest cover type maps (1980 1:100000) and two sets of air-photos (1979 1:50000 and 1982 1:60000) were obtained for the study area. The area was extensively burned in 1979 as was evident on the most recent air-photos. Large areas on the photos had a relatively uniform black color with no identifiable vegetation. We used the 1982 air-photos to locate unburned sites for investigation and to identify community types on these sites. Vegetation maps were not drafted for the study area due to the extent of the 1979 burn.

Access to study sites was by small motor boat. Most study sites were located within a few hundred meters of the lake shore. The rugged rock outcrops and abundance of burned deadfall made long-distance overland travel difficult. Most site types, however, could be accessed close to the lake shore. Twelve sites were chosen for intensive plant community and soil descriptions. Sites were considered suitable for sampling if they were relatively homogeneous over a 0.5 hectare area, were free of

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human disturbance and, in all but 1 site, they were not burned in the most recent fire. Forms from the Natural Areas program were used for vegetation and site descriptions. A 10 m x 10 m plot at each site was used to estimate plant species cover to the nearest percent. Two or three tree cores were taken at each site to obtain a stand origin date and to assess population age structure. We also tried to determine the factors influencing stand establishment and its successional status

We described the surficial geology and noted the following site characteristics: aspect, slope, exposure type, site position on a slope, surface shape, flood hazard, ecological moisture regime, soil drainage and perviousness.

Soil pits were dug in each of the 12 stands in which plant communities were described. The major soil horizons were identified and described in terms of depth, color, pH, condition of the lower boundary, moisture, texture, and structure. All analysis was done in the field. Soils were classified using the keys of Strong and Limbird (1981) and the Canadian System of Soil Classification (Anonymous 1987). Soil nomenclature follows the Canadian System of Soil Classification.

Plants were collected in each of the 12 studied stands and along lake and stream shores. All vascular plants were collected in plastic bags and pressed on return to camp. Non-vascular plants were collected in paper bags and were not processed until returning to the Provincial Museum (P.M.A.). We identified all vascular and most non-vascular plants in the field for inclusion on stand data sheets.

Upon return to the Provincial Museum we identified all vascular and non-vascular species. Species nomenclature for the vascular plants follows Moss (1983). Mosses were identified using Ireland (1982) and their nomenclature follows Ireland et al. (1987). Most lichens were identified using the keys of Fink (1935) and Hale (1979). Their nomenclature follows Egan (1987). All specimens have been deposited in the P.M.A. herbarium (PMAE).

To determine the geographic significance of the flora, comparisons were made with distributions of vascular plants found in the descriptions and maps of Hultén (1968), Porsild and Cody (1980) and Moss (1983). Biogeographic zones used were those described by Raup (1947). Lichen distributions were taken from the descriptions and maps of Thomson (1984) and Bird and Marsh (1972, 1973). Bryophyte distributions were taken from general descriptions provided in Schofield (1969). Details of the biogeographic analysis are described in the floristic section below.

ENVIRONMENT OF THE ANDREW LAKE REGION

Physiography

Andrew Lake lies on the extreme western edge of the Canadian Shield in the Churchill structural province. An ancient peneplain, the shield has been planed down through long periods of erosion. The Churchill structural province forms a giant horseshoe extending from Lake Athabasca-Great Slave Lake, across the interior barrens, along western Baffin Island and into the Ungava Peninsula of northeastern Quebec. The largest subdivision of this province is the Kazan Upland which includes all of the Canadian Shield which occurs in northeastern Alberta. The topography of the Kazan Upland is composed of "residual round-topped hills...[which] rise a few hundred feet above the general level, but these hills are not as a rule connected into definite ranges nor aligned in any particular direction." (Camsell and Malcom 1921 in Raup 1946).

The Kazan Upland north from Lake Athabasca is composed of hard granites and gneisses which are highly resistant to erosion. Soil development is minimal due to the limited weathering of these highly resistant rocks. Southward and westward of Lake Athabasca lie sedimentary deposits of the Pre-Cambrian and Paleozoic respectively.

Glacial History

Glaciers of the Pleistocene Epoch have significantly altered the landscape of northeastern Alberta "by rounding and levelling rock ridges, scouring out hollows, and depositing a shallow layer of stoney, sandy till" (Clayton et al. 1977). The Wisconsin ice advance has had the largest impact on the present landscape and it destroyed much of the evidence of preceding glaciations. The Kazan Upland in northeastern Alberta has been largely affected by glacial erosion. Most of the till was carried off the upland

and deposited onto the Interior Plains to the southwest.

According to Godfrey (1963), about 60% of the area is bedrock leaving only a small proportion of the area covered by muskeg. Deep till deposits are uncommon in the region and most of it fills depressions and cracks in the bedrock. Much of the till is sandy or silty and lacks cohesion (Clayton et al. 1977). A sandy glacial outwash plain occurs on the south shore of Andrew Lake.

Longitudinal ice-flow features, which are common in the Kazan Upland, are lacking in the area around Andrew Lake. Likewise, well-developed disintegration moraine is almost absent in this area.

The main result of the Wisconsin glaciation on the Alberta portion of the Canadian Shield has been a disruption of the pre-existing drainage network and a scouring of the landscape. This has created a large number of lakes occupying the glacially eroded depressions. In the highly eroded areas of the shield, including Andrew Lake, the lakes and rivers show a strong pattern of bedrock control. The lake shore is often determined by structural features such as fault lines or by lithological conditions (Godfrey 1963). Rivers show a strong trellis pattern indicating fault-line control or erosion along lines of geologic weakness.

Climate

The climate of the Andrew Lake study area is poorly known. There are no weather stations in the area and no fire towers close to the lake. The closest recording weather stations are at Fort Smith, Northwest Territories, and at Uranium City, Saskatchewan. Because of its higher elevation, Andrew Lake may be expected to have greater precipitation and somewhat cooler summer temperatures than either of these two stations.

Andrew Lake, along with Fort Smith and Uranium City, lies within the Boreal Northlands ecoregion as defined by Strong and Leggat (1981). They predicted that mean annual precipitation in this ecoregion will be between 300 and 450 mm, with summer precipitation possibly as low as 200 mm. This may be drier than the area around Bistcho Lake which is expected to have an annual precipitation range of between 400 and 450 mm. Summer precipitation at Bistcho Lake is expected to be as high as 300 mm. The drier conditions at Andrew Lake may be due to a rainshadow effect as westerly flowing air has to rise over both the Cameron Uplands and the Caribou Mountains before reaching Andrew Lake in the Kazan Uplands.

The May to September mean temperature at Andrew Lake would be about 11°C, which is about 1°C warmer than the Boreal Subarctic conditions of Bistcho Lake and about 1°C cooler than the more southerly Boreal Mixedwood ecoregion. The mean frost-free period should be about 85 days (Strong and Leggat 1981), considerably longer than the 60 days predicted for the Bistcho Lake region. However, the mean December to February temperature is about -24.0°C which is colder than the Boreal Mixedwood ecoregion and is expected to be colder than the Boreal Subarctic ecoregion. Temperature inversions associated with the Arctic High Pressure System are expected to provide higher temperatures to the higher elevation Boreal Subarctic sites.

VEGETATION, PLANT COMMUNITY AND SOIL DESCRIPTIONS

Figure 1 shows the locations of the stands we sampled around Andrew Lake. Table 1 shows the environmental and species percent cover data collected from each of the described stands.

The two most prominent features in the Andrew Lake landscape are lakes and rolling hills of massive granitic rock and boulders. Extensive areas of bedrock were exposed by a large fire in 1979 which destroyed over 80% of the vegetation cover. Thus, aside from small pockets of vegetation which escaped this fire, the majority of the vegetation is in the early stages of post-fire recovery.

The vegetation of the Andrew Lake region is similar to that of the High Boreal ecoregion in the adjacent Northwest Territories as described by Bradley et al. (1982). *Pinus banksiana* is dominant on rocky uplands and areas of glacial outwash. *Picea mariana* is found mixed with *P. banksiana* on moist sites. *Picea mariana* dominates on the upland muskegs and on bogs/wetlands found along the lakeshore. *Picea mariana* can also form moderately dense stands where there are somewhat finer textured soils. *Betula papyrifera*, the dominant deciduous tree species, is found scattered throughout

Figure 1. Locations of stands sampled for soils and vegetation at Andrew Lake. Stand 6 is located at Waugh Lake, 10 km southeast of Andrew Lake.

Table 1. Environmental attributes and species percent cover of the surveyed stands in the Andrew Lake study area.

Stand No.	1	2	3	4	5	6	7	8	9	10	11	12
Slope	5	5	0	1	0	2	15	7	2	3	2	10
Aspect	ESE	NE	N	SSW	N	E	SSE	WNW	WN	WESE	E	W
Soil Moisture	M	SH	SD	SH	SH	X	SM	SM	H	SX	M	M
Drainage	I	P	VP	P	P	R	MW	MW	P	W	MW	P
Soils	EEB	OLG	-	OC	OC	OR	OEB	EDB	OC-GTC	EEB	EEB	OLG
Trees												
Betula papyrifera	1	17						0.1				
Larix laricina				0.1					0.5			
Picea mariana	3	6		5	0.1			25	15	0.5		25
Pinus banksiana	15					1	5				15	
Populus tremuloides										15		
Tall and medium shrubs												
Alnus crispa	1	4	0.5			0.5			0.5			
Betula papyrifera						2	0.5			0.5	3	0.1
Betula pumila			3	3	0.5							
Larix laricina			0.5	0.1	0.1							
Picea mariana		2		1	0.5		1	2	1	0.5	0.5	
Pinus banksiana					0.1	0.5						
Populus tremuloides					0.1	0.5				1		
Rosa acicularis										0.5		
Salix sp.			0.5			0.1						
Salix bebbiana											0.1	
Salix planifolia				0.5								
Viburnum edule										0.5		
												cont.

Soil Moisture: SD=subhydric, H=hydric, SH=subhygric, M=mesic, SX=subxeric, X=xeric

Drainage: VP=very poor, P=poor, I=imperfect, MW=moderately well, W=well, R=rapid

Soils: EEB=Eluviated Eutric Brunisol, EDB=Eluviated Dystric Brunisol, OEB=Orthic Eutric Brunisol, OC=Organic Cryosol, GTC=Gleysolic

Table 1. cont.

	1	2	3	4	5	6	7	8	9	10	11	12
Low shrubs and forbs												
Amelanchier alnifolia							0.5					
Agrostis scabra						0.5	0.1					
Andromeda polifolia			1	2	0.5							
Arctostaphlos uva-ursi	0.5					4	8			15		
Campanula rotundifolia						0.5						
Carex sp.									0.1			
Carex aquatilis			1	0.1								
Carex xerantica							0.1					
Chamaedaphne calyculata			5	4	1				0.5			
Cornus canadensis									0.5		0.5	
Corydalis sempervirens							0.1					
Cryptograma acrostichoides						0.5						
Drosera rotundifolia									0.1			
Empetrum nigrum				0.5					0.5			
Epilobium angustifolium					0.1	0.1				0.1	0.1	
Equisetum fluviatile			0.1									
Equisetum scirpoides									0.1			
Equisetum sylvaticum									0.1		0.1	
Geocaulon lividum										0.5		
Juniperus communis						0.1	0.5			0.5		
Kalmia polifolia					0.5							
Larix laricina				1								
Ledum groenlandicum	0.5	2		2	5	0.1			10	2		0.5
Ledum palustre									0.5			
Linnaea borealis										1	0.1	
Lycopodium annotinum											0.5	
Lycopodium complanatum	0.1									3	1	
Lycopodium obscurum		0.5								0.1		
Menyanthes trifoliata			0.1									
Orthilia secunda								0.1		0.5	0.5	
Oryzopsis pungens	0.1					0.5	0.5			0.5		
Oxycoccus microcarpus				0.5	0.5				0.5			
Picea mariana				0.5	1	0.5						
Pinguicula villosa									0.1			
Pinus banksiana						2						

Table 1. cont.

Poa glauca						0.5					
Potentilla palustris			0.5	0.1	1						
Pyrola chlorantha									0.1		
Rubus chamaemorus				0.5				0.5			
Salix myrtillifolia								1			
Salix pedicellaris			1								
Saxifraga tricuspidata					0.5	0.5					
Vaccinium vitis-idaea	20	12		3	2	0.5	0.5	7	5	17	0.5
Lichens and bryophytes											
Arctoparmelia centrifuga		0.1				0.1					
Aulacomnium palustris				1							
Ceratodon purpureus	0.5	0.5				0.1				0.1	
Cetraria ericetorum	0.1										
Cetraria nivalis	0.1				0.1			0.1			
Cladina mitis	5	2			2	2	15	0.5	7	1	1	0.5
Cladina stellaris									0.5			0.1
Cladonia sp.	0.5				1	2	2					
Cladonia cenotea	0.1				0.1							
Cladonia coccifera		0.1			0.5							
Cladonia cornuta		0.1										
Cladonia deformis	0.1				0.1							
Cladonia gracilis	0.5	0.5			0.5	8			0.1			
Cladonia multiformis							0.5					
Cladonia uncialis	0.1	0.1				3						
Cladonia rangiferina					0.1		0.5		3			0.5
Cladonia verticellata						0.1						
Crustose lichens	0.5					7	40					
Dicranum spp.	5				0.5			0.1	0.5	0.1	0.1	
Hedwigia ciliata		0.5				0.5						
Hylocomium splendens	0.5	1						35	4	0.1	5	5
Ichmadophilia ericetorum					0.5							
Peltigera sp.										0.5		
Peltigera apthosa	0.1	0.5					0.5	0.5			0.1	
Peltigera canina				0.5	0.5							
Peltigera leucophlebia				1								

cont.

Table 1. cont.

	1	2	3	4	5	6	7	8	9	10	11	12
Peltigera malacea	0.5						0.1					
Pleurozium schreberi	2	2						45	45		2	80
Polytrichum juniperinum	0.1	0.5		2	1	1			0.5	0.1		
Ptilidium ciliare	2	0.5				0.1		0.5			0.1	
Ptilium crista-castrensis							2					
Sphagnum sp.			25	75	70				10			
Stereocaulon paschale	2	0.5			1	2			0.1			
Tomenthypnum falcifolium				0.1								

upland sites primarily associated with *P. banksiana*. *Populus tremuloides* is found occasionally in small even-aged stands. *Picea glauca* is rare, occurring only as scattered individuals on glacial outwash deposits on the east side of Andrew Lake. The diverse topography in the Andrew Lake area is not reflected in a diversity of plant communities. Only seven plant community types, five upland and two wetland, were identified.

Vegetational differences between the Bistcho Lake region (Hastings and Ellis 1988a) and the Andrew Lake region are due primarily to differences in physiography. An underlying morainal till of silts and clays, low relief, and poor drainage has given rise to extensive *P. mariana* forests on organic soil in the Bistcho Lake region. The *P. mariana* forests are interrupted only on areas of higher relief, and thus better drainage, by mixedwood forests. The vegetation of the Andrew Lake region, on the other hand, has developed on Precambrian bedrock with strong relief and shallow soils. Extensive *P. mariana* forests on organic soils are absent while *P. banksiana* or *P. banksiana* and *P. mariana* on shallow mineral soils are the dominant forest types. Both Andrew and Bistcho Lakes have glacial outwash deposits of sand on which *P. banksiana* is dominant.

The modal soil for the Boreal Northlands ecoregion is a Gray Luvisol developed under Aspen/Spruce forests (Strong and Leggat 1981). However, the Andrew Lake study area is dominated by Regosolic soils because of its extensive rock outcrops and only very shallow till deposits. The thin mantle of drift over a rockland, coupled with a relatively low precipitation regime, have produced a situation where drier, pine communities are dominant. Therefore, where true soils develop, they will be dominantly Brunisolic. Low-lying, wet areas have developed Organic and Organic Cryosolic soils. Gleysolic soils are typical of mid-slope positions with a thin layer of drift, and drainage impeded by near-surface bedrock. *Picea mariana*-feathermoss communities are common on these sites.

Plant Community Types (Cts) and Soil Descriptions

Uplands

Pinus banksiana / Arctostaphylos uva-ursi - Vaccinium vitis-idaea / Cladonia spp. ct

Three stands (1,6,7) were assigned to this ct which is the most extensive in the Andrew Lake area. *Betula papyrifera* and *Picea mariana* are usually present in the tree layer and/or understory layers but have low cover. The low diversity of vascular plant species in the understory is typical of all cts in the Andrew Lake area. Tall and medium shrub layers have few species and are poorly-developed. *Alnus crispa* is the most distinctive species in these layers. *Arctostaphlos uva-ursi* and/or *Vaccinium vitis-idaea* form a well-developed dwarf shrub layer. *Juniper communis* and *Ledum groenlandicum* are the only other characteristic low growing shrubs. There are few forb species in any one stand and these stands generally have very low cover. Notable forb species present include *Oryzopsis pungens*, *Lycopodium complanatum*, *Agrostis scabra*, *Campanula rotundifolia*, *Corydalis sempervirens*, *Cryptograma acrostichoides*, *Poa glauca* and *Saxifraga tricuspidata*. Crustose lichens, *Cladina mitis* and *Cladonia gracilis* are the most common species in the usually well-developed lichen carpet. This ct is structurally similar to the Heath-Lichen Woodland vegetation type described by Bradley et al. (1982).

Brunisolic and Regosolic soil orders are characteristic of this ct. Stand 1 has developed an Eluviated Eutric Brunisol with a 6 cm L-F-H layer and a thin (2 cm) Ah horizon. A well-developed, pinkish gray (5YR 7/2) Ae horizon underlies the Ah horizon. The 9-cm Ae horizon is composed of clayey sands. There is no indication of mottling, and despite its high value, its chroma is also a bit too high to indicate that gleying has occurred. The course textured solum, upslope position, and acidic leaf litter promote rapid leaching and the development of a thick Ae horizon. The very coarse, sandy-rocky Bm horizon, however, is unstructured; clays leached from the Ae horizon have not accumulated in sufficient quantity to bind the coarse particles. At 16 cm there is an impenetrable layer of large broken rock in a sandy matrix. This layer may be a till. The lack of illuviation indicates that this is a Bm horizon. The color, however, is more yellow-brown (7.5YR 5/8 - 10YR 5/6) than would be expected for a Bm developing on the local, red colored bedrock. The pH of the Bm horizon is 5.5, which is high for a soil developing on acidic bedrock of the Kazan Upland. A pH of 5.5 puts this soil on the boundary separating Eutric from Dystric Brunisols; at present, our classification is tentative.

Stand 7 has developed an 18 cm thick Orthic Eutric Brunisol over bedrock. Like stand 1, its Ah horizon is thin (2 cm) but in marked contrast to the well-developed Ae horizon in stand 1, the solum in stand 7 appears to lack an Ae horizon. Its silty substrate may impede the development of an Ae horizon in contrast to the more coarse solum in stand 1. The 12 cm thick Bm horizon is dark brown (7.5 YR 3/2). It is composed of unstructured silt with minor amounts of sand. Clay illuviation is absent. The pH of this horizon is 5.7 indicating that it is a Eutric Brunisol. This stand is located near the shoreline of a small island suggesting that the silts are lacustrine in nature. Stand 7 has the only soil with a silty texture to develop a Brunisolic profile. Other silty soils we examined in the Andrew Lake area have been Gleysols. Stand 7's steep slope may improve run-off and drainage thus allowing for the development of a Brunisol.

Stand 6, located at Waugh Lake, 10 km southeast of Andrew Lake, has developed on the crest of a cliff. The exposed bedrock at this site is typical of the uplands in the Andrew Lake area. Thus, the poorly-developed Orthic Regosol soil of this stand is probably representative of a large area around Andrew Lake. The solum is only 8 cm deep before it reaches unaltered bedrock. This "soil" has formed in a large, shallow depression in the rock. The 3 cm thick L-F-H layer overlies a 2 cm thick Ah horizon. A poorly-developed, 3 cm thick Bmt layer overlies the bedrock. This B horizon is composed of silty clays but shows no evidence of ped development or other structural features. The B horizon was moist, reflecting the water holding capacity of the silty clays, but no gleying or mottling was evident. Given a long period of weathering, this and other Regosolic soils may develop into Brunisols. However, frequent fires, coupled with exposed and eroded upland positions, probably inhibit the accumulation of weathered materials and the development of true soils over much of the Andrew Lake area.

Pinus banksiana / Vaccinium vitis-idaea / Hylocomium splendens ct

One stand (11) has been assigned to this ct. This stand is underlain with thick (27 cm+) sand deposits and has an Eluviated Eutric Brunisol soil profile. *Betula papyrifera* and *Picea mariana* are present in the understory but have low cover. The dwarf shrub layer consisting of *Vaccinium vitis-idaea* (17%) is well-developed. Prominent species in the poorly-developed forb layer include *Lycopodium complanatum*, *Cornus canadensis*, *Orthilia secunda*, *Lycopodium annotinum*, *Lycopodium obscurum*, *Linnaea borealis* and *Equisetum sylvaticum*. The cryptogam layer, which is poorly- to moderately-developed, is characterized by the presence of *Hylocomium splendens*, *Pleurozium schreberi* and *Cladina mitis*.

This stand is near to stand 10 (see below) and like it, has an Eluviated Eutric Brunisol soil profile, although less developed. The Ae horizon is just 2 cm thick, barely qualifying it as eluviated. This horizon, however, is gradational with an overlying dark gray (5YR 4/1) Ah horizon that supports this classification. Both A horizons are composed of a fine sand matrix with large amounts of subrounded cobbles. These cobbles do not appear in the underlying B horizons and their presence is somewhat of a mystery. They may have originated upslope and been deposited in a mass-movement event. The Bm horizon is composed of fine sands with a weakly granular structure. Thus, while there has been some alteration in structure by illuviation, it is not sufficient to warrant classification as a Luvisolic Bt. The Bm is yellow red (5YR 5/8) which is of higher chroma and redder hue than the underlying B/C horizon (10YR 5/3). The Bm horizon appears to have been exposed to more oxidation reactions than the B/C horizon. These horizons had pH values ranging from 6 to 6.5 indicating that the soil is a Eutric Brunisol. Bedrock did not occur within the 27 cm section.

The B/C horizon is composed of very fine sands with a minor amount of silt. This texture, along with the stand's lower slope position may indicate that the soil matrix is of lacustrine origin.

Populus tremuloides / Arctostaphylos uva-ursi ct

One stand (10) has been assigned to this ct. Tree cover notwithstanding, this ct shares many similarities with the preceding ct, including soil characteristics. This stand is underlain by thick (42 cm) sand deposits and has a Eluviated Eutric Brunisol soil profile. *Betula papyrifera* and *Picea mariana* are present in the understory but have low cover. The poorly-developed medium shrub layer is characterized by *Rosa acicularis* and *Viburnum edule*. The well-developed ericaceous dwarf shrubs *Arctostaphylos uva-ursi* (15%) and *Vaccinium vitis-idaea*

(8%) dominate the understory vegetation. The poorly-developed forb layer includes *Lycopodium complanatum*, *Geocaulon lividum*, *Equisetum sylvaticum*, *Orthilia secunda*, *Oryzopsis pungens*, *Pyrola chlorantha* and *Epilobium angustifolium*. *Cladina mitis*, *Peltigera* sp., *Polytrichum juniperinium* and *Hylocomium splendens* are the leading species in the weakly-developed cryptogam layer. The dominance of *Populus tremuloides* in the tree layer makes this ct uncommon in the Andrew Lake landscape.

This stand has one of the best-developed and deepest soil profiles of the sites we investigated. Typical of the Brunisols in the Andrew Lake area, it has only a thin (4cm), dark gray (5YR 3/1) Ah horizon. It has a well-developed, light gray (10YR 6/1) Ae horizon overlying a Bm. The Ae horizon is 8 cm thick ranging from 6 to 14 cm in depth. It has a very deep (14-42 cm) Bm horizon composed of coarse sands. Its reddish-yellow color (7.5YR 7/8) is not as red as might be expected for a typical Brunisol. But it matches the trend in the Andrew Lake area where the Bm's tend to have a more yellow hue. Like stand 11, this Bm horizon has a granular structure. Its pH ranges from 6.0 to 7.0.

Betula papyrifera / Vaccinium vitis-idaea / Cladina mitis ct

One stand (2) has been assigned to this ct. This stand is underlain by thick sand-silt-clay deposits (42 cm+) and has an Orthic Luvic Gleysol soil profile. *Picea mariana* is moderately well-developed in the understory which suggests this ct may be successional to a *P. mariana* dominated ct. *Alnus crispa* (4%) is prominent in the tall and medium shrub layers. *Vaccinium vitis-idaea* (12%) forms a moderately well-developed ericaceous dwarf shrub layer. *Ledum groenlandicum* and *Lycopodium complanatum*, the only other understory vascular plant species present, have very low cover. *Cladina* mitis is the most prominent species in the weakly-developed cryptogam layer. This ct appears to be rare in the Andrew Lake area.

The soil of stand 2 is a well-developed Orthic Luvic Gleysol. The stand occurs on a bench in the bedrock which dips upslope, effectively trapping water between the bench and riser of the bedrock. In addition to water, this pocket in the bedrock also appears to accumulate materials from upslope erosion, accounting for the great depth of this soil. The lowermost, Cg, horizon is composed of sandy silts, indicating that these deposits were probably lacustrine in origin. The bedrock pocket and fine-grained texture of the soil produce an environment where the soil is poorly drained and gleying can occur. The Btg horizon, which extends from 8.5 to 20 cm, has prominent bands of low chroma (7.5YR 7/0) mixed with bands of slightly higher chroma (7.5YR 7/2). The reddish yellow (7.5YR 6/8) Cg horizon is prominently mottled. These bands of low chroma and prominent mottling indicate that this soil is a Gleysol.

The Btg horizon is thick (11.5 cm) and well-developed, appearing to be composed largely of illuvial clay. The thickness of this horizon indicates that this soil is a Luvic Gleysol while the thin (3.5 cm) Ah suggests that it is an Orthic Luvic Gleysol. The soil is mesic in the upper horizons and subhygric in the Cg horizon. These moist mineral soil conditions are probably responsible for the well-developed *B. papyrifera* which occur at this stand.

Picea mariana / Pleurozium schreberi ct

Two stands (8,12) have been assigned to this ct. Stand 8 has developed on a well drained sand and has a Brunisolic soil profile while Stand 12 has developed on poorly drained silts and has an Orthic Gleysolic soil profile. Though developed on two distinctly different soils both stands are remarkably similar in their flora and vegetation structure. *Picea mariana* is present in the tall shrub layer in stand 8 but is absent from the understory of stand 12. *Picea mariana* forms a well-developed (25%) dense overstory cover in both stands. *Orthilia secunda*, *Ledum groenlandicum* and *Vaccinium vitis-idaea*, the only species present in the low shrub and forb layer, have very low cover. The very well-developed feather-moss carpet (80-85%) is dominated by *Pleurozium schreberi* and *Hylocomium splendens*. This ct appears to be uncommon in the Andrew Lake area as stands were found only on islands which escaped the 1979 fire. Stand ages ranged from 81 years B.P. (before present) (stand 8) to 89 years B.P. (stand 12). This ct corresponds to the Moss Forest vegetation type described by Bradley et al. (1982).

The complex soil in stand 8 appears to be a paleosolic Eluviated Dystric Brunisol. At the top of the profile is a 3 cm L-F-H, and an Ah horizon extends from 3 to 10 cm. There is no Ae horizon. However, the Ah horizon increases slightly in value from 5YR 3/1 to 5YR 4/1 down the profile indicat-

ing that eluviation may be occurring. At a depth of 13 cm there is a sharp transition from an overlying reddish yellow (5YR 6/6) horizon which appears to be a contemporary Bmj to an underlying pinkish gray (7.5YR 7/2) horizon which may be a buried Ae. Underlying this pinkish grey horizon, at a depth of 18 cm, the solum again turns more brownish (7.5YR 5/8). The lowermost horizon appears to be a Bm and continues past 20 cm. It is composed of unstructured sands and cobbles. The wide range in particle size of this lowermost horizon indicates that this solum has likely developed on a till. The other horizons in the profile have a granular, sandy matrix. They are probably colluvial in origin, resulting from some mass movement event which buried a soil. The B horizons have a relatively low pH, 4.7, indicating that this soil is a Dystric Brunisol.

Stand 12 has an Orthic Luvic Gleysol with organic material forming a large proportion of the solum. The depth of organic material (18 cm) and absence of an eluvial horizon indicates that this is not a typical Orthic Luvic Gleysol. A 5 cm mat of feathermoss tops the profile. This mat is underlain by a mesic-fibric L-F-H layer from 5 to 15 cm. Next there is a black (5YR 2/1) Ah horizon, 3 cm thick with very little mineral matter. The base of the profile is a 7 cm thick Btg horizon which overlies red granitic bedrock. This horizon is silty and weakly platey throughout with 2 bands of color, a 4.5 cm pinkish gray (5YR 6/2) band overlying a 2.5 cm dark red brown (2.5YR 3/4) band. The pinkish gray band is interpreted as being gleyed, its higher chroma due to the red brown color of the bedrock parent material. Thus we classified the solum as Gleysolic. The thick organic mat, silty soil and impervious bedrock all contribute to this stand's imperfect to poor drainage, despite its midslope position. Like stand 8 this profile exhibits a low pH (4.5).

This stand is on a small island in the middle of the lake. Its location and silty soil suggest that the material of the profile is from lacustrine deposition.

Stand 2 also has an Orthic Luvic Gleysol. Like stand 12 it has developed on silts, and is imperfectly drained and wet throughout the profile. The similar soil profile between these 2 stands, and the occurrence of *Picea mariana* in the understory of one and the overstory of the other, suggests that they are related. It may be that stand 12 represents a later successional stage of the *Betula papyrifera* ct as the former is dominated by *P. mariana,* a species which, as noted above, occurs in the understory of the *B. papyrifera* stand. However, the soil in stand 2 has a much better developed Orthic Luvic Gleysol.

Wetlands

Picea mariana / Ledum groenlandicum / Sphagnum spp. ct

Three stands (4,5,9) have been assigned to this ct. These stands have become established on organic parent materials and exhibit a variety of Cryosolic profiles. This ct is common in the Andrew Lake area. It is found in small bays along shoreline where infilling has occurred and in upland depressional areas. The density of *Picea mariana* varies, but generally has an open appearance. *Larix laricina* is occasionally present in wetter depressions. The very low cover of *Picea mariana* in stand 5 is due to the 1979 fire which destroyed most of the trees. *Betula pumila, L. laricina* and *P. mariana* are the characteristic species present in the weakly-developed tall and medium shrub layers. The dominants in the well-developed low shrub layer are *Ledum groenlandicum, Vaccinium vitis-idaea* and *Chamaedaphne calyculata.* Other prominent species present in the low shrub layer are *Andromeda polifolia* and *Oxycoccus microcarpus.* Characteristic species in the weakly-developed forb layer include: *Potentilla palustris, Rubus chamaemorus, Cornus canadensis, Equisetum scirpoides* and *Equisetum sylvaticum. Drosera rotundifolia* and the rare *Pinguicula villosa* are found on *Sphagnum* hummocks. Both stands 4 and 9 have large circular depressions with the trees leaning into the holes. These appear as "drunken forests", common in areas where ice-rich permafrost has melted and the ground subsequently collapsed. This ct most closely resembles the Heath Bog vegetation type described by Bradley et al. (1982) and the Black Spruce Bog type described by Wallis and Wershler (1983).

Stands 4 and 5 appear to have developed on Organic Cryosols. Frost was reached at depths of 15 and 25 cm respectively with no trace of mineral soil in either profile. Both profiles were made of un- to poorly-decomposed *Sphagnum*. It was not possible to penetrate into the frost table so we do not know if the organic horizons reach the 40 cm depth necessary to confirm their classification as Organic Cryosols. Evidence from stand 9 suggests that they may be mineral based Cryosols.

In stand 9 we dug 2 pits. The first pit is similar to those of stands 4 and 5. The solum, composed of *Sphagnum* mosses, is 18 cm deep. At that depth a solid impenetrable ice layer was reached. The profile appears to be an Organic Cryosol. Unlike stands 4 and 5, the top 4 cm of the profile was dry and the mosses well decomposed. This layer of dry mosses insulates the profile and reduces the thaw depth. We noticed patches of what seem to be drunken forest in the stand and large potholes which appear to have resulted from thermokarst action. We dug another soil pit at the edge of a thermokarst hole and encountered mineral soil at a depth of 17 cm. The ice-rich and cryoturbated mineral soil was composed of clay with pockets of sand and silt. It had swirls of colors ranging from gray (7.5YR 6/0) to brown and strong brown (7.5YR 5/2, 7.5YR 5/8). The gray colors probably result from gleying and the swirls are caused by frost action. This soil is classified as a Gleysolic Turbic Cryosol.

Between the frozen mineral horizon and the overlying organic horizon is a 4 cm thick layer of pure segregation ice. It appears that the melting of this band of ice and the ice-rich mineral horizon are responsible for the stand's drunken forest. The thermokarst collapse may be the result of the 1979 fire which heated the soil and reduced the depth of organic matter insulation. The fact that mineral soil was reached in a pit close to the "Organic Cryosol" and at a depth similar to the frost depth of the first pit indicates that the "Organic Cryosol" is a mineral based Cryosol. Further, these frost depths are similar to those of stands 4 and 5. Stand 4 also has a drunken forest with large thermokarst holes. It seems likely that these 2 stands are also underlain by mineral based Cryosols. It is important to note that all pits were dug in June, which technically is too early in the season to justify their classification as cryosols. However, the well-developed thermokarst features provide strong, if indirect, evidence that the ground has been perennially frozen.

Betula pumila / Chamaedaphne calyculata / Carex aquatilis ct

One stand (3) has been assigned to this ct. This ct is found sporadically as a floating mat along the margin of creek channels and in small embayments along the lake shore. No soil pits were dug in this stand. Usually limited in extent, this ct often forms an ecotone between the *Picea mariana/Ledum groenlandicum/Sphagnum* spp. ct and open water. This ct is characterized by a moderately well-developed medium shrub layer dominated by *Betula pumila.* Other species present in this layer include *Larix laricina, Picea mariana* and *Alnus crispa.* The well-developed low shrub layer is dominated by *Chamedaphne calyculata, Ledum groenlandicum, Andromeda polifolia* and *Salix pedicellaris.*

The poorly-developed forb layer is composed of *Carex aquatilis, Equisetum fluviatile, Menyanthes trifoliata* and *Potentilla palustris.* Cryptogams are absent. This ct is ecologically similar to the Sedge-Shrub Fen vegetation type described by Bradley et al. (1982) and to the Swamp type described by Wallis and Wershler (1983).

FIRE HISTORY

The importance of fire in the boreal forest has been well documented (e.g. Lutz 1956, Rowe and Scotter 1973). Fire is one of the main causes of the vegetation mosaic of the boreal forest, affecting both species composition and vegetation structure. Fire history, including fire frequency and intensity, can be used to assess the impact of fire on plant communities.

Tree cores and sections from fire-scarred trees indicate that there have been 8 fires (1774, 1833, 1872, 1895, 1906, 1916, 1928 and 1979) in the Andrew Lake area in the past 213 years. Fire years established from tree sections are: 1833, 1906 and 1916. Fire years based on evidence from tree cores are: 1774, 1872 and 1928. The 1979 fire year was established from reports of the Alberta Forest Service. Tree section and tree core information suggests that the most extensive fires occurred in 1833, 1872, 1916 and 1979. Trees which were fire-scarred or had their origin in these years are widely distributed in the Andrew Lake area. Evidence for fires in 1895, 1906 and 1928 were found only in localized areas. Though the Andrew Lake area has experienced at least 8 fires in the past 213 years none of the fire-scarred trees had more than a single fire scar.

The 1774 fire record was determined from the origin of a *Pinus banksiana* individual from an island in northwest Andrew Lake. This individual (ht = 9.0 m, DBH = 18.5 cm.) was in a small, open grove of pines on the south end of the island. The majority of these pines bore a single fire scar. The wedge from the fire-scarred tree indicates that these pines experienced a light ground fire in 1833. There

is no evidence of fire on the island since that date. A core from an unscarred *Pinus banksiana* (ht = 9.1 m, DBH = 15.0 cm) approximately 1 km north of this grove yielded an origin date of 1834, confirming the 1833 fire date.

FLORA OF THE ANDREW LAKE AREA

General Flora

In 1978, Canadian Forestry Service staff led a short collecting trip to Andrew Lake, but did not publish their results (J.D. Johnson, pers. comm.). The closest published records for collections on the Alberta portion of the Kazan Upland were done by Vitt (1973) and Wallace and Wershler (1984). Vitt noted the occurrence of some bryophytes rare for Alberta in the Wylie Lake area. Wallace and Wershler's work was done for a proposed Ecological Reserve in the Wylie Lake area and also included collections from the Colin-Woodman Lake area. The study area of both groups of researchers is about 55 km south of Andrew Lake. Earlier workers (e.g. Raup 1936, 1946) apparently did not explore the Kazan Upland in the Wylie-Andrew Lake area.

In this study of the Andrew Lake area, 183 plant taxa were found. This is lower than the 203 taxa we found at Bistcho Lake in 1987 (Hastings and Ellis 1988a). The 109 species of vascular plants found at Andrew include 11 pteridophytes, 5 gymnosperms, 24 monocots and 69 dicots (Appendix 1). At Bistcho Lake (op. cit.), we found 149 vascular plants including 10 pteridophytes, 5 gymnosperms, 38 monocots and 96 dicots. The list of non-vascular flora from Andrew Lake comprises 74 species, including 30 mosses, 6 hepatics and 38 lichens, (Appendix 2). At Bistcho Lake we found 54 species (22 mosses, 2 hepatics and 30 lichens).

The lower species richness of vascular plants at Andrew Lake can be attributed to several factors. First, the soils at Andrew Lake are poorly developed, acidic, and probably nutrient poor. This limits the species which can occupy the region to those that can tolerate these extreme conditions. Second, the Andrew Lake area was almost completely burned in 1979. Much of the already thin soil in the area was eroded from the slopes, exacerbating the nutrient-poor conditions. Third, subarctic and boreal forest vegetation zones meet at Bistcho Lake. Permafrost is widespread and the subarctic element is clearly evident in the vegetation as well as the flora. Further, at Bistcho Lake, there are significant areas of species-rich Poplar forests occupying the clayey till sites as well as more species-poor stands on glacial outwash sites. At Andrew Lake there are only a few sites with permafrost and expression of the subarctic element in the vegetation is much reduced. Aspen forests occur only on glacial outwash sands and are species-poor. There were no clay-rich sites in the Andrew Lake area.

Andrew Lake Vascular Flora Rare in Alberta

Five species that are rare in Alberta were found in the Andrew Lake study area. *Isoetes echinospora* Dur. was collected from 2 m of water. Packer and Bradley (1984) classify *I. echinospora* as rare in Alberta and report its occurrence at 3 sites - two near Fort Chipewyan and one at Jasper. Wallace and Wershler (1984) report that it occurs along the north shore of Lake Athabasca but apparently they did not collect it on the Kazan Upland. Their reference is probably to Raup's (1936) collection from a small lake near Sand Point on Lake Athabasca. Raup's was the first report for this species in the Mackenzie basin. *I. echinospora* was subsequently collected by Cody (1956) in several locations on the north shore of Great Slave Lake. He reported that it had not been collected previously between Lake Athabasca and Great Bear Lake and that his was the second collection in the Mackenzie basin. Our collection at Andrew Lake is apparently the first record for *I. echinospora* on the Canadian Shield in Alberta and may be the fourth record for the province. It may also be the first collection between Lake Athabasca and Great Slave Lake. All collectors report that their specimens were obtained from sandy sites. We concur with Porsild and Cody's (1980) statement that *I. echinospora* is "apparently rare and local although perhaps often overlooked." We probably would not have acquired a specimen had not this specimen been caught up in a trap set for fish.

The second rare species, *Polypodium virginianum* L., is also a pteridophyte. Packer and Bradley (1984) classify this species as rare in Alberta with 4 records for the province. All 4 records are from the northeast corner. One collection is from the Slave River, two are from the Peace-Athabasca Delta

near Fort Chipewyan, and one is from the north shore of Lake Athabasca. Raup reports the species as common in rock crevices in forested parts of the area. Porsild and Cody (1980), referring to the continental N.W.T., state that *P. virginianum* is "Rare or occasional on mossy ledges and cliffs in wooded parts of the Precambrian Shield area...". Wallace and Wershler (1984) collected this species on the Kazan Upland of Alberta and report five previous collections for a total of six; all reports are confined to the Canadian Shield. Our collection at Andrew Lake appears to be the seventh record for the species in Alberta.

Packer and Bradley (1984) report that *Potamogeton robbinsii* Oakes is rare in Alberta with collections from 2 locations. One of these locations may be that of Wallace and Wershler (1984) at Colin Lake and the second is probably from the Coyote Lake Natural Area near Drayton Valley. G. Pegg also collected *P. robbinsii* at Glenevis (PMAE 31988.1.838) but this record was not published. The collection from Andrew Lake is the second record for northeastern Alberta and the fourth known collection in the province. The species apparently is rare in western Canada but its deep water habitat makes collecting difficult. Our specimen was brought up on a fishing line. It is probable that *P. robbinsii* is more common than the literature suggests.

Pinguicula villosa L. has also been reported by Packer and Bradley (1984) as rare in Alberta. They reported only a single collection site, that of Lee et al. (1982) on the Caribou Mountains in central northern Alberta. Fairbarns (1983) subsequently collected *P. villosa* in the Cameron Hills of northwestern Alberta where he reported it to be common on *Sphagnum* hummocks. Wallace and Wershler (1984) collected it in the Wylie Lake area in Black Spruce-*Sphagnum* bogs. We have collected the species both at Bistcho Lake (Hastings and Ellis 1988a) and at Andrew Lake. The collection at Andrew Lake is thus the fifth known location for Alberta and the second for northeastern Alberta. *P. villosa* is predominantly a subarctic plant which, at more southerly latitudes, occurs on *Sphagnum* hummocks in Black Spruce bogs. Given the wide range of the species across northern Alberta, and the common occurrence of its habitat, Hastings and Ellis (1988b) question the rarity status given *P. villosa* in Alberta. We suggest that it is overlooked and undercollected due to its small size and difficult access to its habitat.

The final rare vascular plant which we collected at Andrew Lake was *Senecio cymbalariodes* Buek. Packer and Bradley (1984) show only a single collection for Alberta and that is from Waterton National Park. If our collection is verified, this second record for *S. cymbalariodes* in Alberta is a highly significant range extension within the province.

Andrew Lake Non-Vascular Flora "Rare" or Uncommon in Alberta

Drepanocladus tundrae is a circumboreal arctic-alpine species which inhabits rich fens, open Black Spruce woodlands, and sometimes grows submerged in streams (Janssens 1983). At Andrew Lake we collected this species in a single locality along a small, slowly flowing stream that ran off a rock upland. It was collected in a floating mat of vegetation largely composed of several species of *Carex*. Janssens (1983) indicates only a single site for *D. tundrae* in Alberta, that being in the Valley of Ten Peaks in Banff National Park. He also shows it in British Columbia near Mt. Robson Provincial Park. Unpublished collections of *D. tundrae* from Alberta have been taken from near Hinton (ALTA Vitt 24110 & 30011, PMAE C89.3.52) and Fort McMurray (ALTA Vitt 30074). Most of Janssens site records for North America are from Alaska, the Yukon Territory, and the western District of Mackenzie, although the species stretches through to subarctic Manitoba, Ontario, Quebec and Labrador. *Drepanocladus tundrae* appears to be an uncommon plant in Alberta with the Andrew Lake collection being the first report for the province's Canadian Shield.

At Andrew Lake we collected *Sphagnum balticum* in stand 4, a burned, hummocky *Picea mariana/Ledum groenlandicum/Sphagnum* spp. wetland. There were numerous thaw pockets where ice-rich permafrost had melted and the ground collapsed. Bird (1968) and Vitt (1973) both reported that *Sphagnum balticum* occurred in Alberta. However, in 1977, Vitt and Andrus reported that while *S. balticum* is abundant in northern Canada it "may yet be found in northern Alberta. Previous reports from Alberta are based upon misidentifications". Thus, for a time it appeared that *S. balticum* did not

occur in Alberta. Our specimen, identified by Vitt as *S. balticum*, confirms the presence of this species in Alberta. An unreported specimen was collected by D. Horton (ALTA 6986) 6 miles southeast of Eva Lake in the Caribou Mountains. She records its habitat as being in thaw pockets of a perched bog in a *Picea-Betula-Ledum groenlandicum-Ledum palustre-Sphagnum fuscum-Cladina mitis* community. This habitat closely resembles that of the Andrew Lake specimen. This is a fairly common habitat type in northern Alberta. It is likely that *S. balticum* is not uncommon in the Black Spruce wetlands in the northern part of the province. In addition to our collection at the PMA (PMAE B88.29.40), a voucher of this specimen has been deposited at ALTA.

Sphagnum balticum appears to be fairly common in the subarctic of northern Canada, Alaska, and Greenland. Crum (1984) reports that it grows in wet, oligotrophic bogs. The species is absent both from the Canadian Arctic Islands and from the densely treed areas of the boreal forest. Open, treed muskegs appear to be its preferred habitat. This subarctic distribution pattern apparently is uncommon for the bryophyta (Schofield 1972).

Interestingly, this subarctic distribution pattern is characteristic of another bryophyte which we found at Andrew Lake. *Ulota curvifolia* has only been reported twice from Alberta. Bird (1968b) reported it from Jasper National Park and Vitt (1973) collected it at Wylie Lake, just southeast of Andrew Lake. Vitt's distribution map of *U. curvifolia* shows a pattern much like *S. balticum*, except that the former is also shown to occur in alpine locations. Our specimen was collected at a single site, stand 8, which represents an upland *Picea mariana/Pleurozium schreberi* ct. The specimen was growing in a small, flat "pocket" on a large granitic boulder. This granitic rock habitat is similar to that described by Vitt for his collections at Wylie Lake.

Mountain-Northeastern Alberta Disjuncts

Six species of vascular plants appear to have disjunct distributions between the mountains and the northeastern corner of Alberta. However, examination of Canada-wide distribution maps reveal that the species' ranges are actually continuous; they are connected through the southern N.W.T. They are still of interest because they are rare or uncommon in northeastern Alberta and they represent the arctic-alpine element in the study area.

Cryptogramma acrosthichoides R.Br. is reported to be uncommon in northeastern Alberta. Packer (1983) shows 5 sites in the region - three along the Slave River and two on the north shore of Lake Athabasca. Wallace and Wershler (1984) report it on the Canadian Shield and they collected it just north of Colin Lake on the Kazan Upland. We collected it from both Andrew and Waugh Lakes. These collections represent the seventh collection of *C. acrostichoides* for northeast Alberta and the second for the Kazan Upland. We concur with Wallace and Wershler (1984) that the species is locally abundant on rock outcrops and cliffs. It is probably common on the Canadian Shield of Alberta.

Packer (1983) shows *Calamagrostis purpurascens* R.Br. in 2 sites in northeastern Alberta - one in central Wood Buffalo National Park and one on the Peace-Athabasca Delta. Wallace and Wershler (1984) report that apparently it is rare in northern Alberta but is fairly common in the Colin Lake area. We collected it at Andrew Lake and also in 1987 at Bistcho Lake in northwestern Alberta (Hastings and Ellis 1988a). This appears to be the fourth report of *C. purpurascens* in northeastern Alberta and the fifth report for northern Alberta. Both Hultén (1968) and Porsild and Cody (1980) show northern populations close to Andrew Lake. Porsild and Cody (1980) state that *C. purpurascens* is an arctic-alpine species. Like Bistcho Lake, the Andrew Lake collection probably represents a southern extension of subarctic populations rather than northern extensions from Alberta's mountain areas. At Andrew Lake we collected it on two sandy sites, a *Pinus banksiana*/Lichen woodland and along an airstrip. This resembles habitats described in the literature: sand, gravelly south-facing habitat (Wallace and Wershler 1984); "well-drained, calcareous, sandy or stoney places" (Porsild and Cody 1980); and dry sandy exposed situations (Polunin 1959).

Saxifraga tricuspidata Rottb. occurs in the northern Rockies of Alberta and in the northeast corner of the province. It apparently is uncommon in the northeast, where Packer (1983) shows five collection sites on the Slave River and Peace-Athabasca Delta. Wallace and Wershler (1984) collected *S. tricuspidata* once at Wylie Lake and report it to be common on rocky sites and grassy slopes. We collected

it on a 2 m high sandy beach ridge on the south shore of Andrew Lake. Ours is about the seventh collection of this species from northeastern Alberta.

While Packer (1983) shows *Potentilla hookeriana* Lehm. occurring in the mountains of Alberta, he does not indicate its presence in the northeast corner. The first report of this species on the Canadian Shield of Alberta is that of Wallace and Wershler (1984) who found it in a sage-grassland at Woodman Lake. Ours is the second collection for northeastern Alberta. Hultén (1968) shows *P. hookeriana* occurring from northern Alaska to Great Slave Lake with a disjunct population in the Alberta Rocky Mountains. Porsild and Cody (1980) state that it is an arctic-alpine plant of Asia and northwestern North America. We collected *P. hookeriana* near the top of a high, south-facing cliff at Waugh Lake, about 10 km southeast of Andrew Lake. The rocks at Waugh Lake tend to be more basic than the rest of the Kazan Upland in Alberta. This habitat matches that of Hultén (1968) who describes it as occurring on calcareous rocks and Porsild and Cody (1980) who state it is on rocky and sunny places. Raup (1936) reports that *P. hookeriana* [syn = *P. nivea* L. var. *pentaphylla* Lehm.] is rare or occasional in the Precambrian area of Great Slave Lake. It is likely also rare to uncommon in northeastern Alberta.

Packer (1983) does not show *Antennaria racemosa* Hook. occurring outside the mountains or boreal foothills in Alberta. However, his classification is highly conservative as this species has been recorded in the Hondo-Lesser Slave Lake area (Ross and La Roi 1984) and just north of Fort McMurray (La Roi et al. 1987). *A. racemosa* is not reported from the Northwest Territories by either Hultén (1968) or Porsild and Cody (1980). Wallace and Wershler (1984) did not report it in their study of the Kazan Upland. Our collection, from a granitic rock outcrop at Waugh Lake, may be the first report of *A. racemosa* on the Canadian Shield of Alberta.

Arnica lonchophylla Greene spp. *lonchophylla* is uncommon in northeastern Alberta. Packer (1983) shows five collection locations in this region, three along the Slave River and two in central Wood Buffalo National Park. Wallace and Wershler (1984) collected it in 2 locations around the Wylie Lake area and report that it is "occasional in open sandy and rocky woodlands". We collected *A. lonchophylla* in an open sandy area along an airstrip at Andrew Lake. This subspecies is restricted to northwestern North America and ranges from interior Alaska to northern Ontario along Hudson Bay (Hultén 1968, Porsild and Cody 1980).

Boreal Forest Species Uncommon or Rare in Northeastern Alberta

In the Andrew Lake region we found 10 species of vascular plants which, although common and widespread in the boreal forest of Alberta, are relatively uncommon in its northeast corner. *Cystopteris fragilis* (L.) Bernh. is common in the mountains and extends to Lesser Slave Lake. However, Packer (1983) reports only 2 locations in northern Alberta, one along the Peace River at Fort Chipewyan and one on the Peace-Athabasca Delta. These sites apparently refer to Raup's (1936) report. Wallace and Wershler (1984) state that *C. fragilis* is scarce and has "not been found anywhere on the Canadian Shield north of Lake Athabasca...". They did not collect this species in their study of the Kazan Upland. We collected *C. fragilis* on a south-facing cliff at Waugh Lake. This appears to be the third record for northern Alberta and the first for the Kazan Upland.

Evidently, *Carex houghtoniana* Torr. is uncommon in Alberta and rare in the northern part of the province. Packer (1983) reports only 7 locations in Alberta. Previously, the northernmost site is just north of Fort McMurray; other locations are generally south of Lesser Slave Lake. Packer (1983) states that it is found in "dry sandy or gravelly places". We found our specimen along a sandy airstrip on the south shore of Andrew Lake. This is the second report of *C. houghtoniana* for northeastern Alberta. It is not reported for the Northwest Territories (Hultén 1968, Porsild and Cody 1980).

Another uncommon *Carex* in Alberta is *C. umbellata* Schk. Packer (1983) reports only 7 locations in Alberta, none further north than Lesser Slave Lake. Scogan (1979) reports a collection by Richardson at Fort Chipewyan but this is not referred to by Packer. Wallace and Wershler (1984) report that *C. umbellata* is occasional in sandy sites in the Wylie Lake region. We collected this species at 2 locations at Andrew Lake, one along a sandy airstrip and one on a granitic outcrop. These appear to be the second

or third records for *C. umbellata* in northern Alberta and may represent the northern limits of this species in Canada.

Carex xerantica Bailey is uncommon in northern Alberta and has not been reported in the northeast corner (Packer 1983). It has been collected in several southern and central Alberta locations as well as at Peace River and Fort Vermillion. We collected *C. xerantica* on two sandy sites at Andrew Lake. These are the first records for northeastern Alberta. Packer (1983) lists this as a prairie and plains species ranging from southern British Columbia to southern Manitoba and south to Colorado and Minnesota. The collection at Andrew Lake represents the northern limit of *C. xerantica* in Canada.

For Alberta, Packer (1983) shows *Ribes glandulosa* Grauer at 1 location on the Peace-Athabasca Delta and many locations between Fort McMurray and Lesser Slave Lake. Wallace and Wershler (1984) did not report it from their study of the Kazan Uplands. Fairbarns (1983) and Hastings and Ellis (1988a) report its occurrence in northwestern Alberta. *R. glandulosa* may be uncommon on the Canadian Shield of Alberta, but its common occurrence in the southern Northwest Territories and in central Alberta, suggests it has been missed by previous collectors in the northeastern region.

Prunus virginianum L. is commonly found in the southern Boreal Forest, the mountains and prairies in Alberta (Packer 1983). It is uncommon or rare in northern Alberta and has not been reported north of Fort McMurray. Porsild and Cody (1980) report *P. virginianum* at only 2 sites north of 60°N throughout Canada. We collected our specimen in an unburned Jack Pine-White Birch stand on sandy soil at Andrew Lake. This is the second report from northeastern Alberta and it is the most northerly record for the province. It is the first report of *P. virginianum* from the Canadian Shield of Alberta.

According to Packer's (1983) distribution map, *Utricularia minor* L. is uncommon in Alberta with only 10 locations reported. Only 3 records are from the northeast: one from the Fort Smith region, one from central Wood Buffalo National Park and one from south of Lake Athabasca. Porsild and Cody (1980) also suggest that this species is not common in the Northwest Territories. Wallace and Wershler (1984) did not collect *U. minor* on the Kazan Upland of Alberta despite collecting both *U. intermedia* Hayne and *U. vulgaris* L. The collection of *U. minor* from Andrew Lake is the fourth from northeastern Alberta and the first from Alberta's Canadian Shield. It was collected from a small, slowly-flowing stream entering a major channel on the south shore of Andrew Lake. Raup (1936) collected it on Lake Athabasca in Saskatchewan and stated that it was probably common in shallow lake margins in the Lake Athabasca to Great Slave Lake area though it was not often collected.

Antennaria rosea Greene is shown by Packer (1983) to be uncommon in northeastern Alberta. His 5 site locations, apparently all taken from Raup's (1936) report, are: three on the Peace-Athabasca Delta, one on the Slave River near Fort Smith, and one in eastern Wood Buffalo National Park. *A. rosea* was not collected by Wallace and Wershler (1984) in their study of the Kazan Upland. Our specimen was collected on a granitic rock outcrop at Waugh Lake. While this may be the first record of *A. rosea* for the Canadian Shield of Alberta, it is likely not uncommon in the region. Raup (1936) predicted that the species would be common in dry upland woods between Lake Athabasca and Great Slave Lake. Porsild and Cody (1980) indicate that *A. rosea* is abundant in the area south of Great Slave Lake as well as on the Shield to the east.

Northern Species Not Found in the Mountains

In addition to *Pinguicula villosa,* discussed above, two other species of high boreal forest to subarctic plants which are uncommon in Alberta were found in the Andrew Lake region. Unlike the "disjuncts" discussed above, *Myrica gale* L. and *Ledum palustre* L. have not been reported from the mountains of Alberta.

Myrica gale is shown by Packer (1983) to occur only in northern Alberta with 1 site in the Cameron Hills and about 6 sites between Fort McMurray and the Peace-Athabasca Delta. Porsild and Cody (1980) report that it is "probably common throughout the wooded parts of the Precambrian Shield area..." and reaches north almost to the treeline. They show it to be very common in the southern District of Mackenzie. Wallace and Wershler (1984) found *M. gale* to be common along sandy and rocky shorelines and stream banks in the Wylie Lake region in the Kazan Upland. We found it in similar

habitats at Andrew and Waugh Lakes. *M. gale* is probably fairly common around lake shores in the Kazan Upland of Alberta.

Packer (1983) shows that *Ledum palustre* occurs in 8 sites scattered across northern Alberta with a single southern record near Lesser Slave Lake. Hastings and Ellis (1988a) found *L. palustre* to be fairly common in the Bistcho Lake area of northwestern Alberta. For northeastern Alberta, Wallace and Wershler (1984) report that this species is not found on the Shield and occurs no further north than Sand Point on the west shore of Lake Athabasca. Apparently they are referring to Raup (1936) who cited the latter collection location. Raup also stated that the species was occasional on Lake Athabasca and in Wood Buffalo National Park. Unfortunately he appears to have made only the single collection at Sand Point and does not state whether the cited Wood Buffalo Park area was in the Northwest Territories or in Alberta. We found *L. palustre* in Black Spruce forests at Andrew Lake. Ours may be the first record of this species on the Canadian Shield of Alberta. Given its widespread distribution in northern Alberta, and the common occurrence of its habitat, *L. palustre* may be more common in northern Alberta than implied in the literature.

Other Records

Four species from Andrew Lake are common in Alberta but may be rare on the Canadian Shield of northeast Alberta. *Betula pumila* L. is very common in central Alberta but Wallace and Wershler (1984) claim a first record for the Canadian Shield of Alberta. Given that *B. pumila* is very common both south of Great Slave Lake and on the Shield to the east of the Lake (Porsild and Cody 1980), it is also probably common on Alberta's Canadian Shield.

Wallace and Wershler (1984) report that *Anemone multifida* Poir. and *Anemone patens* L. are uncommon or scarce in dry woodlands on the Kazan Upland of Alberta. They claim the first record for *A. multifida* on Alberta's Canadian Shield. We found both of these species in open Jack Pine stands at Andrew Lake.

Geranium bicknellia Britt. is a common weedy species in Alberta, however, Wallace and Wershler (1984) state that it is not found on the Canadian Shield north of Lake Athabasca. We found the species growing along a sandy airstrip at Andrew Lake.

Phytogeography of the Bistcho Lake Flora

Vascular Flora

The method used to describe the biogeography of the Andrew Lake flora is the same as that used by Hastings and Ellis (1988a) for the Bistcho Lake flora. Details of our method and assumptions can be found in that paper. Briefly, the distribution of the region's taxa were classified according to Raup's (1947) system, which in turn was a modification of Hultén's (1937) work. Species in common with the Bistcho Lake flora were classified into the ranges we had previously assigned them. The maps in the floras of Hultén (1968) and Porsild and Cody (1980) were used to determine the ranges of the remaining species. As in the Bistcho Lake study, vascular plants which could be identified only to genera are excluded from analysis. The ranges of 107 vascular plants are considered here.

Some changes were made between the Andrew Lake and Bistcho Lake studies. The classification of range attributed to some species in our Bistcho paper have been changed (e.g., *Vaccinium vitis-idaea* has been assigned a Pacific coast rather than a strictly continental distribution). None of the changes were major, all species remained within their main distribution pattern. Further, it was decided to simplify the coastal classification system as a detailed breakdown did not contribute significantly to an understanding of the biogeography of the Andrew Lake flora. Therefore, species are classified only as being either Pacific coastal or continental.

The flora of Andrew Lake falls into seven main distributions including Raup's original 6 and 1 additional grassland/parkland range (Appendix 3). These ranges are described in detail by Raup (1947) and briefly outlined in Hastings and Ellis (1988a).

The largest floristic group found in the Andrew Lake area belongs to the "Wide-Ranging Forest species." Just over 80% of the flora, 86 taxa, range throughout the forest regions of Canada and Alaska, though some extend onto the tundra. The largest subgroup (46.5%) of forest species (40 species, 37% of total) occur along the Pacific Coast as well as in

the boreal forest but do not occur in tundra regions. The second largest group (37%) does not occur along the Pacific Coast ranges and is also limited by treeline. This group of 32 species (30% of total) represent the typical boreal forest element of the Andrew Lake flora. This breakdown in floristic affinity of forest species is similar to that observed at Bistcho Lake. At Bistcho Lake, 80% of the flora were Wide-Ranging Forest species, and 33% of these forest species were limited by treeline and were not coastal. About 16% of the Andrew Lake and 20% of the Bistcho Lake species have their main distributions in the forest and also extend onto the arctic and/or alpine tundras.

The second largest major group represent "Wide-Ranging Subarctic-Subalpine species". These species represent 7.5% of the Andrew Lake flora, slightly less than the 10% they represented at Bistcho Lake. "Wide-Ranging Arctic-Alpine" and "Alaskan-Cordilleran species" both have 3 species, each representing slightly less than 3% of the flora. Cordilleran species that are exclusively continental make up less than 2% of the flora. In total (excluding cosmopolitan species), 15% of the vascular taxa from the Andrew Lake area have dominantly arctic-subarctic, alpine-subalpine, or cordilleran affinities. This is very close to the 17% of vascular taxa from Bistcho Lake which have a similar distribution. With the addition of "Wide-Ranging Forest species" which have taxa ranging onto the tundra, about 28% of the Andrew Lake flora has some arctic, subarctic, or cordilleran affinity. Thirty-three percent of the Bistcho Lake flora have a similar affinity.

Based on this simplistic floristic analysis it appears that the vascular flora of the Andrew Lake area is predominantly boreal with a large proportion of these forest plants having coastal populations. An arctic-subarctic element is well represented in the flora although few of the species have predominantly arctic or alpine distributions. At Bistcho Lake the arctic-subarctic element is evident in the large expanses of Black Spruce wetlands. At Andrew Lake, Black Spruce wetlands are greatly reduced, thus, subarctic species have lower cover. Well-drained Jack Pine stands predominate and the vegetation is similar to a high boreal forest rather than a subarctic forest. This classification agrees with that of Strong and Leggat (1983) and coincides with work done by Bradley et al. (1982) in the adjacent Lockhart River area of the N.W.T.

Bryophyte Flora

The collection from Andrew Lake included 30 species of mosses and 6 species of liverworts (Appendix 2). The distribution patterns of the mosses were largely taken from Vitt et al. (1988) and our classification of bryogeography follows their format. Distributions of *Sphagnum* spp. were taken from Crum (1984) and were confirmed by Vitt (pers. comm. 1989). Distributions of *Drepanocladus* spp. were taken from Janssens (1983). The distributions of species which we collected but were not included in Vitt et al. were either confirmed by Vitt (pers. comm.) or by examining specimens at ALTA. Hepatic distributions were also taken from Vitt et al. (1988) and were confirmed using Bird and Hong (1975).

Of the 30 species of moss, 27 (90%) are typical boreal forest inhabitants of western North America. Of these, two species, *Plagiothecium laetum* and *Tomenthypnum falcifolium*, are largely restricted to the boreal forest and do not range into the subarctic or tundra nor do they range into alpine areas. Twenty-five species (83%) have ranges that include both the boreal forest and subarctic-subalpine zones. Twenty of the mosses (67%) range into the arctic with 19 of these also being found in the subarctic and boreal forest. Three species, *Drepanocladus tundrae, Sphagnum balticum,* and *Ulota curvifolia* are not typical residents of the boreal forest (see discussion in Flora). According to Janssen's (1983), *D. tundrae* is an arctic-alpine species, but his maps indicate that it also extends southward into the subarctic. *Sphagnum balticum* and *Ulota curvifolia* are particularly interesting as they both have subarctic distribution patterns. Neither species is found in the tundra nor do they range widely in the southern boreal forest. This subarctic distribution pattern apparently is uncommon among the bryophyta (Schofield 1969).

All the hepatics which were identified to species are common residents in the boreal forest. Four of the species (*Anastrophylum minutum, Marchantia polymorpha, Mylia anomala* and *Ptilidium ciliare)* range into the subarctic and subalpine as well as the boreal forest. *Lophozia longidens* is found in boreal and montane forests and in the subalpine but it is not found typically in the subarctic (Bird and Hong 1975, Vitt et al. 1988). Three of the above hepatics, *Anastrophylum minutum, Marchantia polymorpha* and *Ptilidium ciliare* are wide-ranging. They extend

from the boreal forest northwards into the arctic and upslope high into the alpine.

Lichen Flora

Thirty-eight species of lichens were collected at Andrew Lake (Appendix 2). Species distribution patterns were again largely taken from Vitt et al. (1988). These distributions were checked against those shown in Thomson (1984). Distributions for species not appearing in Vitt et al. were taken from Thomson. The distribution of *Tuckermannopsis merrillii* (as *Cetraria merrillii)* was taken from Bird (1972) and Hale (1979).

All 38 species of lichens, with the possible exception of *Tuckermannopsis merrillii,* are common boreal forest residents. Seven of the 38 (18%) are almost exclusively boreal forest or southward residents and do not occur in arctic-alpine or subarctic-subalpine areas. *Tuckermannopsis merrillii* seems to be largely a resident of Alaska and the Cordilleran areas of western North America. Thirty-one of the species (82%) have ranges that include subarctic-subalpine areas as well as the boreal forest while 23 species (60%) also reach into arctic-alpine areas.

Cetraria ericetorum is considered by Krnefelt (1979) to occur primarily in alpine tundra with minor pockets throughout the boreal forest in more exposed sites. *Cladonia amaurocreaea* has an almost subarctic distribution pattern although it is common in the northern parts of the boreal forest (Thomson 1984). It is not prevalent in either the tundra, subalpine, or southern boreal forest.

The distribution patterns of the non-vascular plants support the contention that the Andrew Lake flora is composed largely of species from the boreal forest realm with significant incursions of arctic-alpine, and subarctic-subalpine elements. The high representation of species which range into the arctic is not surprising given the wide ecological tolerances of much of the boreal forest non-vascular flora.

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Appendix 1. Vascular flora from Andrew Lake.

Lycopodiaceae	
Lycopodium annotinum L.	Stiff Club-moss[1]
Lycopodium complanatum L.	Ground Cedar
Lycopodium obscurum L.	Tree Club-moss
Isoetaceae	
Isoetes echinospora Dur.	Braun's Quillwort
Equisetaceae	
Equisetum arvense L.	Common Horsetail
Equisetum fluviatile L.	Swamp Horsetail
Equisetum scirpoides Michx.	Dwarf Scouring Rush
Equisetum sylvaticum L.	Woodland Horsetail
Polypodiaceae	
Cryptogramma acrostichoides R.Br.	Parsely Fern
Cystopteris fragilis (L.) Bernh.	Fragile Fern
Polypodium virginianum L.	Rock Tripe
Cupressaceae	
Juniperus communis L.	Ground Juniper
Pinaceae	
Larix laricina (Du Roi) K. Koch	Tamarack
Picea glauca (Moench) Voss	White Spruce
Picea mariana (Mill.) BSP.	Black Spruce
Pinus banksiana Lamb.	Jack Pine
Sparganiaceae	
Sparganium sp.	Bur-reed
Potamogetonaceae	
Potamogeton robbinsii Oakes	Robins' Pondweed
Gramineae	
Agrostis scabra Willd.	Hair Grass
Calamagrostis purpurascens R.Br.	Purple Reed Grass
Festuca saximontana Rydb.	Sheep Fescue
Hierchloe odorata (L.) Beauv.	Sweet Grass
Oryzopsis pungens (Torr.) A.S. Hitchc.	Northern Rice Grass
Poa glauca Vahl.	Pacific Bluegrass
Poa pratensis L.	Kentucky Bluegrass
Cyperaceae	
Carex aquatilis Wahlenb.	Water Sedge
Carex chordorrhiza L.f.	Prostrate Sedge
Carex concinna R.Br.	Beautiful Sedge
Carex diandra Schrank	Two-stamened Sedge
Carex houghtoniana Torr.	Sand Sedge
Carex lasiocarpa Ehrh.	Hairy-fruited Sedge
Carex limosa L.	Mud Sedge

Carex siccata Dewey	Hay Sedge
Carex umbellata Schk.	Umbellate Sedge
Carex xerantica Bailey	White-scaled Sedge
Eriophorum brachyantherum Trautv.	Cotton Grass
Eriophorum polystachion L.	Cotton Grass
Araceae	
Calla palustris L.	Water Arum
Liliaceae	
Smilacina trifolia (L.) Desf.	Three-leaved Solomon's-seal
Orchidaceae	
Calypso bulbosa (L.) Oakes	Venus' Slipper
Salicaceae	
Populus balsamifera L.	Balsam Poplar
Populus tremuloides Michx.	Aspen
Salix bebbiana Sarg.	Beaked Willow
Salix myrtillifolia Anderss.	Myrtle-leaved Willow
Salix pedicellaris Pursh	Bog Willow
Salix planifolia Pursh	Flat-leaved Willow
Myricaceae	
Myrica gale L.	Sweet Gale
Betulaceae	
Alnus crispa (Ait.) Pursh	Green Alder
Alnus tenuifolia Nutt.	River Alder
Betula papyrifera Marsh	
var. subcordata (Rydb.) Sarg.	White Birch
Betula pumila L.	
var. glandulifera Regel.	Dwarf Birch
Santalaceae	
Geocaulon lividum (Richards.) Fern.	Northern Comandra
Caryophyllaceae	
Stellaria longipes Goldie	Long-stalked Chickweed
Nymphaeaceae	
Nuphar variegatum Engelm.	Yellow-pond Lily
Ranunculaceae	
Anemone multifida Poir.	Cut-leaved Anemone
Anemone patens L.	Pasque Flower
Fumariaceae	
Corydalis sempervirens (L.) Pers.	Pink Corydalis

cont.

Appendix 1. cont.

Droseraceae	
Drosera rotundifolia L.	Round-leaf Sundew
Saxifragaceae	
Saxifraga tricuspidata Rottb.	Three-toothed Saxifrage
Grossulariaceae	
Ribes glandulosum Grauer	Skunk Currant
Ribes hudsonianum Richards	Wild Black Currant
Ribes oxyacanthoides L.	Wild Gooseberry
Ribes triste Pall.	Wild Red Currant
Rosaceae	
Amelanchier alnifolia Medic.	Saskatoon
Potentilla hookeriana Lehm.	Snow Cinquefoil
Potentilla palustris (L.) Scop.	Marsh Cinquefoil
Potentilla tridentata Ait.	Three-toothed Cinquefoil
Prunus virginiana L.	Choke Cherry
Rosa acicularis Lindl.	Prickly Rose
Rubus arcticus L.	Dwarf Raspberry
Rubus chamaemorus L.	Cloudberry
Rubus idaeus L.	Wild Red Raspberry
Geraniaceae	
Geranium bicknellia Britt.	Bicknell's Geranium
Empetraceae	
Empetrum nigrum L.	Crowberry
Elaeagnaceae	
Shepherdia canadensis (L.) Nutt.	Canadian Buffalo-berry
Onagraceae	
Epilobium angustifolium L. *ssp. angustifolium* L.	Fireweed
Haloragaceae	
Myriophylum exalbescens Fern.	Spiked Water-milfoil
Araliaceae	
Aralia nudicaulis L.	Wild Sarsaparilla
Cornaceae	
Cornus canadensis L.	Bunchberry
Pyrolaceae	
Orthilia secunda (L.) House	One-sided Wintergreen
Pyrola asarifolia Michx.	Common Pink Wintergreen
Pyrola chlorantha Sw.	Greenish-flowered Wintergreen

Appendix 1. cont.

Ericaceae	
Andromeda polifolia L.	Bog Rosemary
Arctostaphylos rubra (Rehder & Wils.) Fern.	Alpine Bearberry
Arctostaphylos uva-ursi (L.) Spreng.	Common Bearberry
Chamaedaphne calyculata (L.) Moench	Leather Leaf
Kalmia polifolia Wang.	Pale Laurel
Ledum groenlandicum Oeder	Common Labrador Tea
Ledum palustre L.	Northern Labrador Tea
Oxycoccus microcarpus Turcz.	Small Bog Cranberry
Vaccinium vitis-idaea L.	Bog Cranberry
Apocynaceae	
Apocynum androsamaefolium L.	Spreading Dogbane
Menyanthaceae	
Menyanthes trifoliata L.	Buck-bean
Hydrophyllaceae	
Phacelia franklinii (R.Br.) A. Gray	Franklin's Scorpion Weed
Lentibulariceae	
Pinquicula villosa L.	Small Butterwort
Utricularia minor L.	Small Bladderwort
Caprifoliaceae	
Linnaea borealis L.	Twin-flower
Viburnum edule (Michx.) Raf.	Low-bush Cranberry
Campanulaceae	
Campanula rotundifolia L.	Harebell
Compositae	
Achillea millefolium L.	Common Yarrow
Achillea sibirica Ledeb.	Many-flowered Yarrow
Antennaria racemosa Hook.	Racemose Everlasting
Antennaria rosea Greene	Rosy Everlasting
Arnica loncophylla Greene	Spear-leaved Arnica
Hieracium sp.	Hawkweed
Petasites sagittatus (Pursh) A.	Gray Arrow-leaved Coltsfoot
Senecio cymbalariodes Buek	Ragwort
Solidago spathulata DC.	Mountain Goldenrod
Sonchus arvensis L.	Perennial Sow Thistle

1. Common names from Anonymous (1988)

Appendix 2. Biogeography of the non-vascular flora of Andrew Lake.

Species	Distribution
MOSSES	
Aulocomnium palustre	Ar-Al,Sa-Sa,Bf
Bryum pseudotriquetrum	Ar-Al,Sa-Sa,Bf-Ca +
Ceratodon purpureus	Ar-Al,Sa-Sa,Bf-cosmo
Dicranum polysetum	Sa-Sa,Bf
Dicranum undulatum	Sa-Sa,Bf
Drepanocladus revolvens	Ar-Al,Sa-Sa,Bf-Ca +
Drepanocladus tundrae	Ar-Al,Sa-
Drepanocladus uncinatus	Ar-Al,Sa-Sa,Bf
Hedwigia ciliata	Ar-Al,Sa-Sa,Bf-cosmo
Hylocomium splendens	Sa-Sa,Bf
Philonotus fontana	Ar-Al,Sa-Sa,Bf-Ca +
Plagiothecium laetum	Bf
Pleurozium schreberi	Sa-Sa,Bf
Pohlia nutans	Ar-Al,Sa-Sa,Bf-cosmo
Polytrichum juniperinum	Ar-Al,Sa-Sa,Bf
Polytrichum strictum	Ar-Al,Sa-Sa,Bf
Ptilium crista-castrensis	Sa-Sa,Bf
Rhytidium rugosum	Ar-Al,Sa-Sa,Bf-Ca +
Sphagnum angustifolium	Sa-Sa,Bf
Sphagnum balticum	Sa
Sphagnum capillifolium	Ar-Al,Sa-Sa,Bf
Sphagnum fuscum	Ar-Al,Sa-Sa,Bf
Sphagnum girgensohnii	Ar-Al,Sa-Sa,Bf
Sphagnum magellanicum	Ar-Al,Sa-Sa,Bf
Sphagnum russowii	Ar-Al,Sa-Sa,Bf
Sphagnum subsecundum	Ar-Al,Sa-Sa,Bf
Sphagnum warnstorfii	Ar-Al,Sa-Sa,Bf-Ca +
Thuidium abietinum	Ar-Al,Sa-Sa,Bf-Ca +
Tomenthypnum falcifolium	Bf
Ulota curvifolia	Sa-Sa
HEPATICS	
Anastrophyllum minutum	Ar-Al,Sa-Sa,Bf
Asterella sp.	
Lophozia longidens	-Sa,Bf
Marchantia polymorpha	Ar-Al,Sa-Sa,Bf
Mylia anomala	Sa-Sa,Bf
Ptilidium ciliare	Ar-Al,Sa-Sa,Bf

LICHENS

Arctoparmelia centrifuga	Ar-Al,Sa-Sa
Bryoria fuscescens	-Sa,Bf
Cetraria ericetorum	Ar-Al,Sa-Sa,Bf
Cetraria nivalis	Ar-Al,Sa-Sa,Bf
Cladina mitis	Ar-Al,Sa-Sa,Bf
Cladonia rangiferina	Ar-Al,Sa-Sa,Bf
Cladonia stellaris	Sa-Sa,Bf
Cladonia amaurocraea	Sa- , Bf
Cladonia bacillaris	Bf
Cladonia cenotea	Ar-Al,Sa-Sa,Bf
Cladonia chlorophaea	Ar-Al,Sa-Sa,Bf-cosmo
Cladonia coccifera	Ar-Al,Sa-Sa,Bf
Cladonia comuta	Ar-Al,Sa-Sa,Bf
Cladonia crispitata	Ar-Al,Sa-Sa,Bf
Cladonia deformis	Ar-Al,Sa-Sa,Bf
Cladonia gracilis	Ar-Al,Sa-Sa,Bf-cosmo
Cladonia multiformis	Sa-Sa,Bf
Cladonia phyllophora	Sa- ,Bf
Cladonia pleurota	Sa- ,Bf
Cladonia pyxidata	Ar-Al,Sa-Sa,Bf-cosmo
Cladonia sulphurina	Bf
Cladonia uncialis	Ar-Al,Sa-Sa,Bf
Evernia mesomorpha	Bf
Hypogymnia physodes	Ar-Al,Sa-Sa,Bf
Icmadophila ericetorum	Ar-Al,Sa-Sa,Bf
Parmelia sulcata	Ar-Al,Sa-Sa,Bf
Parmelia ambigua	Ar-Al,Sa-Sa,Bf
Peltigera apthosa	Ar-Al,Sa-Sa,Bf
Peltigera canina	Ar-Al,Sa-Sa,Bf-cosmo
Peltigera leucophlebia	Ar-Al,Sa-Sa,Bf
Peltigera malacea	Sa-Sa,Bf
Stereocaulon paschale	Ar-Al,Sa-Sa,Bf
Tuckermannopsis americana	Bf
Tuckermannopsis merrillii	Ar-Al, Sa (Alaska-Cord)
Tuckermannopsis pinastri	Sa-Sa,Bf
Usnea hirta	Bf
Usnea subfloridina	Bf

Ar-Al = Arctic-Alpine
Sa-Sa = Subarctic-Subalpine
Bf = Boreal Forest
cosmo = cosmopolitan
Ca+ = calciphile

Wide-ranging forest species/tundra/Pacific coast

Equisetum scirpoides Michx.
Hierchloe odorata (L.) Beauv.
Potentilla palustris (L.) Scop.
Rubus chamaemorus L.
Empetrum nigrum L.
Epilobium angustifolium L. ssp. *angustifolium* L.
Myriophylum exalbescens Fern.
Orthilia secunda (L.) House
Ledum groenlandicum Oeder
Oxycoccus microcarpus Turcz.
Vaccinium vitis-idaea L.
Campanula rotundifolia L.

Wide-ranging forest species/tundra/continental

Stellaria longipes Goldie
Petasites sagittatus (Pursh) A. Gray

Wide-ranging forest species/boreal forest/Pacific coast

Lycopodium annotinum L.
Lycopodium complanatum L.
Lycopodium obscurum L.
Isoetes echinospora Dur.
Equisetum fluviatile L.
Equisetum sylvaticum L.
Cryptogramma acrostichoides R.Br.
Juniperus communis L.
Potamogeton robbinsii Oakes
Agrostis scabra Willd.
Poa pratensis L.
Carex lasiocarpa Ehrh.
Carex limosa L.
Carex umbellata Schk.
Eriophorum polystachion L.
Calypso bulbosa (L.) Oakes
Populus balsamifera L.
Populus tremuloides Michx.
Salix bebbiana Sarg.
Geocaulon lividum (Richards.) Fern.
Anemone multifida Poir.
Corydalis sempervirens (L.) Pers.
Drosera rotundifolia L.
Ribes hudsonianum Richards
Ribes triste Pall.

Rosa acicularis Lindl.
Rubus idaeus L.
Geranium bicknellia Britt.
Shepherdia canadensis (L.) Nutt.
Cornus canadensis L.
Pyrola asarifolia
Pyrola chlorantha Sw.
Arctostaphylos uva-ursi (L.) Spreng.
Kalmia polifolia Wang.
Menyanthes trifoliata L.
Utricularia minor L.
Linnaea borealis L.
Viburnum edule (Michx.) Raf.
Achillea millefolium L.
Antennaria rosea Greene

Wide-ranging forest species/boreal forest/continental
Polypodium virginianum L.
Larix laricina (Du Roi) K. Koch
Picea glauca (Moench) Voss
Picea mariana (Mill.) BSP.
Pinus banksiana Lamb.
Festuca saximontana Rydb.
Oryzopsis pungens (Torr.) A.S. Hitchc.
Carex concinna R.Br.
Carex diandra Schrank
Carex houghtoniana Torr.
Carex siccata Dewey
Calla palustris L.
Smilacina trifolia (L.) Desf.
Salix myrtillifolia Anderss.
Salix pedicellaris Pursh
Alnus crispa (Ait.) Pursh
Alnus tenuifolia Nutt.
Betula papyrifera Marsh var. *subcordata* (Rydb.) Sarg.
Betula pumila L. var. *glandulifera* Regel.
Nuphar variegatum Engelm.
Ribes glandulosum Grauer
Ribes oxyacanthoides L.
Amelanchier alnifolia Medic.
Potentilla tridentata Ait.
Prunus virginiana L.
Rubus arcticus L.
Aralia nudicaulis L.

cont.

Chamaedaphne calyculata (L.) Moench
Apocynum androsamaefolium L.
Phacelia franklinii (R.Br.) A. Gray
Achillea sibirica Ledeb.
Solidago spathulata DC.

Wide-ranging arctic alpine/boreal forest/Pacific coast
Poa glauca Vahl.
Saxifraga tricuspidata Rottb.

Wide-ranging arctic alpine/boreal forest/continental
Calamagrostis purpurascens R.Br.

Wide-ranging subarctic-subalpine/pacific coast
Eriophorum brachyantherum Trautv.
Myrica gale L.
Andromeda polifolia L.
Arctostaphylos rubra (Rehder & Wils.) Fern.
Ledum palustre L.
Pinquicula villosa L.

Wide-ranging subarctic-subalpine/continental
Carex chordorrhiza L.f.
Salix planifolia Pursh

Alaska-cordilleran
Anemone patens L.
Potentilla hookeriana Lehm.
Arnica loncophylla Greene

Cordilleran/continental
Antennaria racemosa Hook.
Senecio cymbalariodes Buek

Grassland/parkland
Carex xerantica Bailey

Cosmopolitan
Equisetum arvense L.
Cystopteris fragilis (L.) Bernh.
Carex aquatilis Wahlenb.
Sonchus arvensis L.

ACULEATE WASPS (HYMENOPTERA) [WITH THE EXCEPTION OF THE FORMICIDAE] OF ANDREW LAKE

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INTRODUCTION

The aculeata, one of the three major divisions of Hymenoptera, include ants, predatory wasps and bees. This study deals with the aculeate fauna of Andrew Lake: the Chrysidoidea, Vespoidea (except Formicidae) and Apoidea (except apiformes). Species of the following families were collected– CHRYSIDOIDEA: Chrysididae; VESPOIDEA: Vespidae, Pompilidae; APOIDEA: SPHECIFORMES: Sphecidae, Pemphredonidae and Crabronidae. The following article provides a tabular summary of the Andrew Lake aculeate wasp fauna, a comparison with the Yukon fauna and a comparison with other Alberta study sites. It discusses faunal relationships, trophic levels, nest site preferences, host preferences and provides an annotated list of the Andrew Lake fauna except Formicidae.

Andrew Lake, located in extreme northeastern Alberta, lies on the Canadian Shield in the Northwestern Boreal Uplands (Danks 1979). The area is characteristic of Canadian Shield with thin soils (< 10 cm) bedrock outcrops, and a subarctic boreal forest with a mosaic of open lichen forest and wetland. Additionally, the entire area was subject to a burn in 1979 and provided a unique opportunity to sample post-burn invertebrate fauna.

Three sites were selected for sampling, two on the southwestern lake shore and one midway on its east shore. The southern sites were in young, seral Jack Pine/ericad/lichen woodland (hereafter referred to as "young seral pine habitat") and a seral mixed White Spruce-Aspen forest with a burned-out understory (hereafter referred to as "White Spruce-Aspen habitat"). The third site, midway on the east Lake shore was a sandy beach, its trees had also been burned over. Sampling devices included pan traps in all three habitats, Malaise traps in the young seral pine and the sandy beach habitats, and sweep samples from the young seral pine habitat. Sampling procedures and specimen handling were the same as outlined in Finnamore (1988).

ACULEATE WASP FAUNA OF ANDREW LAKE

The samples from Andrew Lake produced 167 specimens of aculeate wasps representing 30 species. Table 1 lists these species and indicates habitat and numbers of specimens collected. Of the habitats sampled, the young seral pine proved to be most diverse with 80% of collected species. The sandy beach and the White Spruce-Aspen habitats both produced about 40% of the total species collected. Of the 30 species collected, 18 (60%) were unique to single habitats; the young seral pine habitat contained 66% of the unique species and the sandy beach habitat contained the other 34% of the unique species. There were no species unique to the White Spruce-Aspen habitat, although 20% (6) of the species occurring there were also found in the young seral pine habitat. An additional 17% (5 species) were common to all 3 sample sites. There were no species occurring in both sandy beach and White Spruce-Aspen habitats that did not occur in the young seral pine habitat. Finally, only 1 species was common to both sandy beach and young seral pine habitats, aside from those 5 species which were common to all three habitats.

Table 2 compares the fauna of Andrew Lake with two other habitats in Alberta and with cumulative Alberta and Yukon faunas. The table indicates the numbers of species in each aculeate wasp family occurring at Andrew Lake, Bistcho Lake, Wagner Natural Area, Alberta and the Yukon Territory.

The Andrew Lake and Bistcho Lake samples represent short term collections; the Wagner sample is a collection conducted for the duration of insect activity during a single year. The Alberta sample is the cumulative data from the preceding. The Yukon sample is cumulative data from literature and col-

lections over many years compiled for an article on the aculeate wasps of the Yukon (Finnamore, in press). Because the samples collected at Andrew and Bistcho Lakes are short term, caution must be exercised when comparing the fauna between these and other localities. Insect faunas undergo a seasonal succession, and it is because of this succession, and the variability of the season itself, that the most ecologically significant collections are obtained by sampling for the duration of activity throughout the year.

The Andrew Lake fauna consists of 30 species. In terms of the number of species (Table 3), it most resembles that of Bistcho Lake (25 species) and least resembles that of the Yukon (148 species). The slightly greater number of species at Andrew Lake, compared with Bistcho Lake, may be due to the effects of fire promoted habitat diversity. The Wagner fauna, with 69 aculeate wasp species, illustrates the difference in number of species collected between short-term sampling programs (Bistcho and Andrew) and sampling for the duration of activity throughout a year. Table 3 depicts the number of species Andrew Lake has in common with other areas. Bistcho Lake shared the fewest species with Andrew with 43% of Andrew Lake species present at both sites. Fifty percent of the species at Andrew Lake were also found at Wagner, while 90% of Andrew Lake species are known from the Yukon. Table 4 depicts the similarity of these faunas with Andrew using the Wagner Index:

$$SI = \frac{2\,(\#\text{ species shared between sites A \& B})}{\text{total species at sites A + B}}$$

The higher the figure, the more similar the faunas. Andrew Lake is most similar to Bistcho Lake (SI = .61) and least similar to Wagner and Yukon (SI = .36). Although 90% of the species at Andrew also occur in the Yukon they represent only 18% of the Yukon fauna and consequently the two sites are not as similar as shared species may indicate.

GEOGRAPHIC RELATIONSHIPS

The fauna of Andrew Lake is dominated by species demonstrating transcontinental distribution patterns. Table 5 shows the predominance of northern elements (holarctic and transcontinental) in Andrew, Bistcho and the Yukon faunas (83%, 83% and 70% respectively). The Yukon fauna is relatively rich in western species (28%), those species distributed west of the 100th meridian, while both Andrew and Bistcho Lakes are relatively poor in western species (13% and 17% respectively). The mountainous nature of most of the Yukon may account for its relatively greater proportion of western species, although incomplete sampling in Alberta localities may also account for the discrepancy.

NEST SITE PREFERENCE

Predatory aculeate wasps nest in a number of different habitats: sand, soil, gravel, decaying wood, stems, twigs, galls or they construct mud or paper nests. Preexisting cavities in any of the preceding habitats, including abandoned insect borings in wood, may also be used as nest sites. Table 6 depicts nest site preference in predatory aculeate wasps (parasitoids and cleptoparasitoids excluded) at 3 locations: Andrew Lake, Bistcho Lake and the Yukon. Both the Yukon and Andrew Lake faunas exhibit a pattern typical of the Nearctic fauna where ground nesting species predominate approximately three to one. The apparent anomalous records at Bistcho Lake are the result of sampling which emphasized bog conditions, a habitat low in ground nesting species.

TROPHIC RELATIONSHIPS

Aculate wasps can be divided into 4 groups: herbivore (a few vespid pollen feeders), parasitoid, cleptoparasitoid and predator. Parasitoids are those species where the larva develops internally (endoparasitoid) or externally (ectoparasitoid) in or on a single host individual. The predator and parasitoid strategies should be viewed as a continuum where the predator is an ectoparasitoid usually requiring several host individuals to complete larval development. Cleptoparasitoids are those species attacking other aculeate wasps or bees where the larva kills the host egg or larva and consumes the food provisioned for the host. Table 7 summarizes trophic levels at 3 sites: Andrew Lake, Bistcho Lake and the Yukon Territory. In the Nearctic Region, the parasitoid component of the aculeate wasp fauna is a considerable 35% while none of the localities in this study exceeded 10%. Thus all 3 localities exhibit a low parasitoid component. This is typical of northern areas, due to the absence of several parasitoid groups which are represented in more southern areas (Bethylidae 201 Nearctic species, Tiphiidae 236 Nearctic species and Mutillidae 467 Nearctic species). By contrast, the clep-

toparasitoid component is high (23 - 29%) compared to the Nearctic (8%). Finnamore (in press) noted this phenomenon in the Yukon fauna and speculated that it is part of the general increase in cleptoparasitoid species west of the 100th meridian.

HOST PREFERENCES

Aculeate wasps use a number of insect and spider groups as hosts, Table 8 summarizes the groups used by the Andrew, Bistcho and Yukon faunas. At all 3 sites hemimetabolous and holometabolous insects are utilized in roughly equal proportions. Andrew Lake differs from the other 2 localities in that nearly twice the proportion of species utilize Araneae (spiders) as hosts, 33% as compared with 18% and 19% at the other sites respectively. Additionally, a very low proportion of Homoptera are used as hosts at Andrew Lake, 6% as compared with 23% and 24% at the other sites.

Table 1. Checklist and habitats of the aculeate wasps of Andrew Lake.

SP = young seral pine habitat
SB = sandy beach habitat
WS = White Spruce-Aspen habitat
 # SP = number of specimens collected.

	SP	WS	SB	# SP
CHRYSIDOIDEA: Chrysididae				
1. *Chrysis coerulans* Fabricius	x			1
2. *Chrysura (Olochrysis) pacifica* (Say)	x	x	x	15
VESPOIDEA: Vespidae				
3. *Vespula (Vespula) austriaca* (Panzer)	x	x		13
4. *Vespula (Vespula) intermedia* (Buysson)			x	1
5. *Vespula (Vespula) vulgaris* (Linnaeus)	x	x		22
6. *Vespula (Dolichovespula) albida* (Sladen)	x		x	2
7. *Vespula (Dolichovespula) arctica* (Rohwer)	x			1
8. *Vespula (Dolichovespula) arenaria* (Fabricius)	x	x	x	18
9. *Vespula (Dolichovespula) norvegicoides* (Sladen)	x	x	x	6

cont.

Table 1. cont.

Pompilidae	SP	WS	SB	#SP
10. *Evagetes crassicornis consimilis* (Banks)	x			2
11. *Evagetes crassicornis crassicornis* (Shuckard)	x			1
12. *Evagetes parvus* (Cresson)	x			2
13. *Evagetes subangulatus* (Banks)	x			1
14. *Episyron oregon* Evans			x	1
15. *Anoplius (Arachnophroctonus) insolens* (Banks)	x			1
16. *Anoplius (Arachnophroctonus) tenebrosus* (Cresson)	x	x	x	32
17. *Anoplius (Anoplius) nigerrimus* (Scopoli)	x	x		2
18. *Anoplius (Anoplius) tenuicornis* (Tournier)	x			1
19. *Ammosphex michiganensis michiganensis* (Dreisbach)	x			1
20. *Arachnospila arctus* (Cresson)			x	1
21. *Arachnospila fumipennis fumipennis* (Zetterstedt)	x	x	x	10
22. *Anoplochares apicatus* (Provancher)			x	1
APOIDEA: SPHECIFORMES: Sphecidae				
23. *Podalonia luctuosa* (Smith)			x	2
Pemphredonidae				
24. *Pemphredon (Cemonus) inornata* Say	x	x		2
25. *Passaloecus cuspidatus* Smith	x			1
Crabronidae				
26. *Tachysphex seminufus* (Cresson)	x	x		13
27. *Trypoxylon aldrichi* Sandhouse	x	x		10
28. *Crabro* sp. near *helvocrinus* R. Bohart			x	1
29. *Ectemnius (Ectemnius) borealis* (Zetterstedt)	x			1
30. *Ectemnius (Ectemnius) dives* (Lepeletier & Brulle)	x			2
TOTAL	**24**	**11**	**12**	**167**

Table 2. Summary of aculeate wasp species at various locations in western Canada.

Family	Andrew	Bistcho	Wagner	Alberta	Yukon	TOTAL
Bethylidae	0	0	4	4	1	5
Chrysididae	2	3	7	8	23	25
Dryinidae	0	1	8	8	6	11
Embolemidae	0	0	0	0	1	1
CHRYSIDOIDEA	2	4	19	20	31	42
Sierolomorphidae	0	0	0	0	1	1
Sapygidae	0	1	1	1	2	2
Vespidae	7	11	14	17	18	22
Pompilidae	13	4	12	20	30	36
VESPOIDEA	20	16	27	38	51	61
Sphecidae	1	0	0	1	4	4
Pemphredonidae	2	3	11	12	18	22
Astatidae	0	0	0	0	7	7
Crabronidae	5	2	11	14	30	36
Nyssonidae	0	0	1	1	6	6
Philanthidae	0	0	0	0	1	1
APOIDEA: SPHECIFORMES	8	5	23	28	66	76
Total aculeate fauna	**30**	**25**	**69**	**86**	**148**	**179**

Table 3. Species shared between various western Canadian localities and Andrew Lake.

Family	Total Andrew	Bistcho	Wagner	Alberta	Yukon	Andrew Unique
Bethylidae	0	0	0	0	0	0
Chrysididae	2	1	1	1	1	0
Dryinidae	0	0	0	0	0	0
Embolemidae	0	0	0	0	0	0
CHRYSIDOIDEA	2	1	1	1	1	0
Sierolomorphidae	0	0	0	0	0	0
Sapygidae	0	0	0	0	0	0
Vespidae	7	6	5	6	7	0
Pompilidae	13	3	5	7	12	0
VESPOIDEA	20	9	10	13	19	0
Sphecidae	1	0	0	0	1	0
Pemphredonidae	2	1	2	2	2	0
Astatidae	0	0	0	0	0	0
Crabronidae	5	2	2	3	4	1
Nyssonidae	0	0	0	0	0	0
Philanthidae	0	0	0	0	0	0
APOIDEA: SPHECIFORMES	8	3	4	5	7	1
Total aculeate fauna	**30**	**13**	**15**	**19**	**27**	**1**
Percentage	100	43	50	63	90	3

Table 4. Species similarity (Wagner) between Andrew Lake and other western faunas.

	Bistcho	Wagner	Alberta	Yukon
Andrew	.61	.36	.39	.36

Table 5. Geographic relationships of the Andrew Lake, Bistcho Lake and Yukon Territory aculeate wasp faunas.

	Holarctic	Transcontinental	Northern Total	Western
Andrew (30 sp.)	6 (20%)	19 (63%)	25 (83%)	4 (13%)
Bistcho (23 sp.)	6 (26%)	13 (57%)	19 (83%)	4 (17%)
Yukon (141 sp.)	20 (14%)	79 (56%)	99 (70%)	39 (28%)

Table 6. Nest site preference of aculeate wasps.

	Ground Nesting	Decaying Wood	Aerial Nesting
Andrew Lake	15 (65%)	2 (9%)	6 (26%)
Bistcho Lake	5 (36%)	0	9 (64%)
Yukon Territory	73 (69%)	12 (11%)	21 (20%)

Table 7. Trophic relationships of aculeate wasps.

	Parasitoids	Cleptoparasitoids	Predators
Andrew Lake	0	8 (26%)	22 (73%)
Bistcho Lake	2 (8%)	7 (29%)	15 (63%)
Yukon Territory	9 (6%)	35 (23%)	110 (71%)

Table 8. Host preferences of aculeate wasps.

Host	Andrew L.	Bistcho L.	Yukon T.
Araneae	10	3	27
Orthoptera	1	1	4
Hemiptera	0	0	7
Homoptera	2	4	34
Hemimetabolous Total	**13 (43%)**	**8 (47%)**	**72 (50%)**
Coleoptera	0	0	3
Diptera	3	0	24
Lepidoptera	6	3	12
Hymenoptera	8	6	34
Holometabolous Total	**17 (57%)**	**9 (53%)**	**73 (50%)**

ANNOTATED CHECKLIST OF ACULEATE HYMENOPTERA FROM ANDREW LAKE WITH THE EXCEPTION OF THE FORMICIDAE

Superfamily Chrysidoidea

The Chrysidoidea is essentially a tropical group of 7 families containing an estimated 13,500 species. Four families (Bethylidae, Chrysididae, Dryinidae and Embolemidae) and 124 species are represented in Canada. Although all Canadian families are present in the Yukon, only the Chrysididae were collected at Andrew Lake.

Family Chrysididae

Members of this family reach their greatest diversity in the tropics. The described world fauna, about 3,000 species, represents 50% of the estimated 6,000 species thought to exist. The 60 species found in Canada are, for the most part, restricted to the extreme south, although 23 species were recently reported from the Yukon (Finnamore, in press). Members of the Canadian fauna exhibit a wide range of behavior. Most are cleptoparasitoids on other solitary aculeate wasps and bees. Other species are parasitoids on tenthredinoid sawfly larvae (Hymenoptera: Symphyta) and at least one species in southern Canada is a parasitoid attacking the eggs of stick insects.

1. ***Chrysis coerulans* Fabricius** 1 female.

Distribution: transcontinental.

Andrew Lake: swept from young seral pine habitat.

Biology: cleptoparasitoid. Host – HYMENOPTERA: VESPIDAE:*Ancistrocerus antilope antilope* (Panzer), *A. catskill albophaleratus* (Saussure), *A. catskill catskill* (Saussure), *A. catskill halophilus* Viereck, *A. spilogaster* Cameron, *A. adiabatus adiabiatus* (Saussure), *A. adiabatus cytainus* (Cameron), *A. tuberculocephalus sutterianus* (Saus-

sure), *Euodynerus foraminatus apopkensis* (Robertson), *E. foraminatus foraminatus* (Saussure),

E. foraminatus scutellaris (Saussure), *E. leucomelas* (Saussure), *E. megaera* (Lepeletier), *Parancistrocerus acarophorus* (Bohart), *P. salcularis rufulus* (Bohart), *Symmorphus albomarginatus* (Saussure), *S. cristatus cristatus* (Saussure). MEGACHILIDAE: *Hoplitis anthocopoides* (Schenk) (Bohart and Kimsey 1982; Krombein *et al.* 1979).

2. *Chrysura (Olochrysis) pacifica* (Say) 15 females.

Distribution: transcontinental south to Mexico: Baja California.

Andrew Lake: specimens were obtained from all habitats sampled, 8 from the young seral pine, 3 from the White Spruce-Aspen and 4 from the sandy beach habitats.

Biology: cleptoparasitoid. Host – HYMENOPTERA: MEGACHILIDAE: *Hoplitis brachyodonta* (Cockerell), *Osmia coloradensis* Cresson, *O. georgica* Cresson, *O. kincaidi* Cockerell, *O. lingaria propinqua* Cresson, *O. marginata* Michener, *O. nigrifrons* Cresson, *O. pumila* Cresson, *O. tanneri* Sandhouse (Bohart and Kimsey 1982).

Superfamily Vespoidea

The Vespoidea is a moderately large, mostly tropical group of 10 families, all of which are represented in Canada (316 species). The Andrew Lake fauna is represented by 3 families: Formicidae, Vespidae and Pompilidae. The Formicidae is not treated in this survey.

Family Vespidae

The Vespidae is a moderately large family, mostly tropical, although the Vespinae (hornets and yellowjackets) are northern. The Nearctic fauna contains 330 species with 62 reported from Canada. Only a single subfamily, Vespinae, was collected at Andrew Lake. The little information available on their behavior indicates they are predators on a wide range of insects, scavengers on decaying carcasses, and a few are cleptoparasitoids on other vespids.

3. *Vespula (Vespula) austriaca* (Panzer) 13 females.

Distribution: Holarctic, transcontinental in Canada, Alaska to Quebec and California.

Andrew Lake: 12 specimens were collected in the young seral pine habitat and 1 specimen from the White Spruce-Aspen habitat.

Biology: inquiline. Host – unknown in North America, but Miller (1961) reported *Vespula austriaca* from nests of *Vespula rufa* (Linnaeus) in Europe.

4. *Vespula (Vespula) intermedia* (Buysson) 1 female.

Distribution: boreal, Alaska to Newfoundland.

Andrew Lake: the single specimen was collected in the sandy beach habitat.

Biology: predator, nest terrestrial? Host – general predator and scavenger.

5. *Vespula (Vespula) vulgaris* (Linnaeus) 22 females.

Distribution: transcontinental, Alaska south to California, Arizona, New Mexico, South Dakota, Iowa, Indiana, Illinois, Ohio, North Carolina, Mexico.

Andrew Lake: 15 specimens were collected in the young seral pine habitat and 7 specimens were collected in the White Spruce-Aspen habitat.

Biology: predator, nest terrestrial or aerial. Host – general predator and scavenger.

6. *Vespula (Dolichovespula) albida* (Sladen) 2 females.

Distribution: boreal, Alaska to Newfoundland.

Andrew Lake: 1 specimen was collected from the young seral pine habitat while the other was collected from the sandy beach habitat.

Biology: predator, nest terrestrial. Host – general predator and scavenger.

7. *Vespula (Dolichovespula) arctica* (Rohwer) 1 female.

Distribution: boreal, Alaska to Newfoundland.

Andrew Lake: the single specimen was collected from the young seral pine habitat.

Biology: inquiline. Host – *Vespula (Dolichovespula) arenaria* (Fabricius).

8. *Vespula (Dolichovespula) arenaria* (Fabricius) 13 females.

Distribution: transcontinental.

Andrew Lake: 11 specimens were collected from the young seral pine habitat, one specimen from the White Spruce-Aspen habitat and one specimen from the sandy beach habitat.

Biology: predator, aerial nest. Host – general predator and scavenger.

9. *Vespula (Dolichovespula) norvegicoides* (Sladen) 6 females.

Distribution: boreal, Alaska to Newfoundland.

Andrew Lake: 4 specimens were collected in the young seral pine habitat, 1 specimen from the White Spruce-Aspen habitat and one specimen from the sandy beach habitat.

Biology: predator, aerial nest in shrubs. Host – general predator and scavenger.

Family Pompilidae

The spider wasps, with 75 Canadian species, are the second largest group of vespoid wasps in Canada; the ants (Formicidae) are larger. The Pompilidae is found across Canada as far north as the tree line and into the southern fringes of the arctic. This study lists 14 species from Andrew Lake although Finnamore (in press) lists 32 species from the Yukon. As their common name suggests, these wasps are predatory on spiders but a few are cleptoparasitoids on other pompilids.

10. *Evagetes crassicornis consimilis* (Banks) 2 females.

Distribution: western, Yukon to California at higher altitudes.

Andrew Lake: both specimens were collected in the young seral pine habitat.

Biology: cleptoparasitoid on other Pompilidae. Host – unknown.

11. *Evagetes crassicornis crassicornis* (Shuckard) 1 male.

Distribution: Holarctic, boreal, Yukon to Nova Scotia south to Washington, North Dakota, Michigan, Pennsylvania.

Andrew Lake: the specimen was collected from the young seral pine habitat.

Biology: cleptoparasitoid on other Pompilidae. Host – unknown.

12. *Evagetes parvus* (Cresson) 2 males.

Distribution: transcontinental in southern Canada, north to Yukon, south to California, Arizona, New Mexico, Texas, Missouri, Georgia and Costa Rica.

Andrew Lake: both specimens were collected in the young seral pine habitat.

Biology: cleptoparasitoid on other Pompilidae. Host – unknown.

13. *Evagetes subangulatus* (Banks) 1 male.

Distribution: Yukon to Labrador, south to California, Arizona, New Mexico, Colorado, South Dakota, Minnesota, Ohio, Georgia.

Andrew Lake: the single specimen was collected in the young seral pine habitat.

Biology: cleptoparasitoid on other Pompilidae. Host – unknown.

14. *Episyron oregon* Evans 1 male.

Distribution: western Canada and United States south to California and Wyoming.

Andrew Lake: the single specimen was collected from the sandy beach habitat.

Biology: predator, sand nester. Host – ARANEAE: ARANEIDAE: *Araneus trifolium* (Hentz) (Krombein *et al.* 1979).

15. *Anoplius (Arachnophroctonus) insolens* (Banks) 1 female.

Distribution: British Columbia to Maine, south to Mexico: Veracruz, Morelos and USA: Texas, Georgia.

Andrew Lake: the single specimen was collected in the young seral pine habitat.

Biology: predator, ground nester. Host – ARANEAE: SALTICIDAE: *Maevia vittata* (Hentz) (Krombein *et al.* 1979).

16. *Anoplius (Arachnophroctonus) tenebrosus* (Cresson) 32 females.

Distribution: Yukon to Newfoundland south to California, New Mexico, South Dakota, Minnesota, Wisconsin, Pennsylvania, Virginia.

Andrew Lake: 23 specimens were collected in the young seral pine habitat, 1 specimen was collected in the White Spruce-Aspen habitat and 8 specimens were collected in the sandy beach habitat.

Biology: predator, sand nester. Host – ARANEAE: LYCOSIDAE: *Lycosa avida* Walckeraer, *L. baltimoriana* Keyserling, *L. frondicola* Emerton, *Schizocosa saltatrix* Hentz, *Tarentula kochi* Keyserling, *Trochosa avara* Keyserling. PHILODROMIDAE: *Thanatus formicinus* (Oliv.). THOMISIDAE: *Xysticus ferox* Hentz, *X. gulosus* Keyserling (Krombein *et al.* 1979).

17. *Anoplius (Anoplius) nigerrimus* (Scopoli) 2 females.

Distribution: Holarctic, transcontinental in Canada and northern United States, Yukon to Newfoundland.

Andrew Lake: 1 specimen was collected in the young seral pine habitat and the other was collected from the White Spruce-Aspen habitat.

Biology: predator, ground nester. Host – unknown.

18. *Anoplius (Anoplius) tenuicornis* (Tournier) 1 male.

Distribution: Northwest Territories to New Brunswick south to New Mexico, Colorado, Manitoba, Vermont.

Andrew Lake: the single specimen was collected in the young seral pine habitat.

Biology: predator, ground nester. Host – unknown.

19. *Ammosphex michiganensis michiganensis* (Dreisbach) 1 male.

Distribution: transcontinental in Canada, Yukon to New Brunswick, south to Georgia, Minnesota, Colorado.

Andrew Lake: the single specimen was collected in the young seral pine habitat.

Biology: predator, ground nester. Host – ARANEAE: THOMISIDAE: *Xysticus conctator* Thorell, *X. ferox* (Hentz), *X. funestus* (Keyserling), *X. transversatus* (Walckenaer) (Krombein *et al.* 1979).

20. *Arachnospila arctus* (Cresson) 1 male.

Distribution: transcontinental in Canada, Yukon and British Columbia to Labrador and Nova Scotia, south to District of Columbia, Iowa, Colorado, New Mexico, Arizona and Mexico: Hidalgo, Mexico.

Andrew Lake: the single specimen was collected in the sandy beach habitat.

Biology: predator, ground nester. Host – ARANEAE: AMAUROBIIDAE: *Amaurobius bennetti* (Blackwall), *A. ferox* Walckenaer. CLUBIONIDAE: *Clubionia* sp. GNAPHOSIDAE: *Orodrassus coloradensis* Emerton. LYCOSIDAE: *Arctosa* sp., *Schizocosa saltatrix* (Hentz), *Trochosa avara* Keyserling (Krombein *et al.* 1979).

21. ***Arachnospila fumipennis fumipennis*** **(Zetterstedt)** 9 males, 1 female.

Distribution: Holarctic, boreal, Alaska to Labrador south to New York, North Dakota, Alberta, Washington.

Andrew Lake: 8 male specimens were collected in the young seral pine habitat, 1 male from the White Spruce-Aspen habitat and the only female from the sandy beach habitat.

Biology: predator, ground nester. Host – unknown.

22. ***Anoplochares apicatus*** **(Provancher)** 1 female.

Distribution: transcontinental in southern Canada, British Columbia to Newfoundland, south to Florida, Texas and California.

Andrew Lake: the single specimen was collected from the sandy beach habitat.

Biology: predator, nests in pre-existing cavities. Host – unknown.

Superfamily Apoidea: Spheciformes

The Apoidea is treated as two informal groups, the Spheciformes or sphecid wasps and the Apiformes or bees. Only the Spheciformes are considered here. The Spheciformes is a group of 9 families, with about 8,000 species, occurring in all zoogeographic regions. Eight families and 283 species are found mainly across southern Canada. The Andrew Lake fauna consists of 3 families and 8 species compared with 6 families and 66 species from the Yukon (Finnamore in press).

Family Sphecidae

The thread waisted wasps are a group of medium to large wasps found around the world; the mud-daubers are included in this group. The Canadian fauna includes 34 species, one of which was collected from Andrew Lake. Members of this family are predators on lepidopterous and hymenopterous larvae, orthopteroids, or spiders.

23. ***Podalonia luctuosa*** **(Smith)** 2 females.

Distribution: transcontinental, boreal south to northern tier of United States and south to California in the west.

Andrew Lake: both specimens were collected in the sandy beach habitat.

Biology: predator, ground nester. Host – LEPIDOPTERA: NOCTUIDAE: *Chorizagrotis auxiliaris* (Grote), *Peridroma saucia* (Hubner) (Krombein *et al.* 1979).

Family Pemphredonidae

Members of the Pemphredonidae are physically among the smallest aphid wasps, some species average only 2 mm in length. There are about 800 species known around the world, the Canadian fauna contains 49 species, 2 of which were collected at Andrew Lake. These wasps are either twig nesting or sand nesting. Prey consists of Homoptera, primarily Cicadellidae and aphids, but some genera prey on Thysanoptera or Collembola.

24. ***Pemphredon (Cemonus) inornata*** **Say** 2 males.

Distribution: transcontinental in Canada and the United States.

Andrew Lake: one specimen was collected from the young seral pine habitat, the other from the White Spruce-Aspen habitat.

Biology: predator, twig nester. Host – HOMOPTERA: APHIDIDAE: *Macrosiphum* sp. (Krombein *et al.* 1979).

25. ***Passaloecus cuspidatus*** **Smith** 1 male.

Distribution: transcontinental in Canada and the United States.

Andrew Lake: the single specimen was collected from the young seral pine habitat.

Biology: predator, twig nester. Host – HOMOPTERA: APHIDIDAE: *Cinara abieticola* (Cholodkovsky), *C. fornacula* Hottes, *Dysaphis plantaginea* (Passerini), *Euceraphis betulae* (Koch), *Macro-*

siphum sp., *Rhopalosiphum fitchii* (Sanderson) (Vincent 1978).

Family Crabronidae

With nearly 3,300 species, this is the largest of the spheciform families. The Canadian fauna contains 99 species, 5 species were collected at Andrew Lake. Nesting behavior is variable; ground, twig and mud nests are constructed by different members of this family. Prey consists for the most part of Orthoptera, Hemiptera, Diptera and spiders.

26. *Tachysphex semirufus* (Cresson) 5 males, 8 females.

Distribution: western, Yukon to California, Arizona, Colorado, Great Lakes area, New Jersey.

Andrew Lake: 12 specimens were collected in the young seral pine habitat and 1 specimen was collected in the White Spruce-Aspen habitat.

Biology: predator, ground nester. Host – ORTHOPTERA: ACRIDIDAE: *Melanoplus spretus* (Walsh)? TETTIGONIIDAE: *Anabrus simplex* Haldemann, *Capnobates* sp. probably *occidentalis* (Thomas) (Pulawski 1988).

27. *Trypoxylon aldrichi* Sandhouse 8 males, 2 females.

Distribution: western, British Columbia, Alberta, south to Wyoming and northern California.

Andrew Lake: 4 males and 1 female were collected from the young seral pine habitat; 4 males and 1 female were collected from the White Spruce-Aspen habitat.

Biology: predator, twig nester. Host – unknown.

28. *Crabro* sp. near *helvocrinus* R. Bohart 1 male.

Distribution: unknown. This apparently new species belongs to the *Crabro thyreophorus* group presently comprising 2 species in North America. The specimen is most closely related to *C. helvocrinus* from California but differs both in structure and coloration. Since only a single specimen is known, description of the species will await accumulation of further material.

Andrew Lake: the specimen was collected in the sandy beach habitat.

Biology: predator, ground nester. Host – unknown.

29. *Ectemnius (Ectemnius) borealis* (Zetterstedt) 1 male.

Distribution: Holarctic, transcontinental in Canada, mountains in western United States.

Andrew Lake: the single specimen was collected in the young seral pine habitat.

Biology: predator, decaying wood nester. Host – unknown.

30. *Ectemnius (Ectemnius) dives* (Lepeletier & Brulle) 2 males.

Distribution: Holarctic, transcontinental in Canadian and Transition Zones of Canada and United States.

Andrew Lake: both specimens were collected in the young seral pine habitat.

Biology: predator, decaying wood nester. Host – DIPTERA: SYRPHIDAE and TACHINIDAE in Europe (Krombein *et al.* 1979).

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GROUND BEETLE (COLEOPTERA: CICINDELIDAE AND CARABIDAE) HABITAT SELECTION AT ANDREW LAKE, ALBERTA

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INTRODUCTION

Having collected ground beetles at Bistcho Lake (Shpeley 1988), I took the opportunity afforded by an expedition to Andrew Lake to obtain comparative material for these two areas of boreal forest in western Canada. One of the important ecological determinants in the statics and dynamics of boreal forest ecosystems is fire. The Andrew Lake area provided the opportunity to study the effects of forest fires on carabid communities because, in 1979, some of the area had been burned.

In addition to discussing the effects of fire, I have made the first attempt at characterizing a carabid assemblage in the boreal forest of North America in terms of moisture preference and activity pattern of adult beetles.

THE STUDY AREA

Several different habitats, ranging from beach sand to original forest not affected by the fire, were sampled at or near the margin of Andrew Lake. Hastings and Ellis (this volume) give an account of the local vegetation. Specimens were collected at a total of 18 sites, some of which were subsequently grouped. As the principal basis for comparison, I recognize the following nine habitat types (AL), based on an assessment of: presence or absence of water; amount, and type of plant cover, predominant tree or shrub growth; and whether or not the area had been burned.

AL1 – sandy beach and lake margin; mouth of creek flowing into lake. The creek mouth is mostly sand, with a few small shrubs and mosses.

AL2 – burned sandy beach and grasses nearby. The burned sandy beach is partially covered with lichens and mosses. The grasses are found at the transition zone between the beach and a burned White Spruce forest.

AL3 – birch-alder, alder-birch-pine, and alder-birch-poplar-pine forests. The birch-alder forest had the understory burned out, the birch remained and the alder is post-fire growth. The other two forests are all new growth in coarse sandy areas where all the trees had been killed by the fire.

AL4 – burned understory. This site extends from the lake margin which was not burned, up a slope on which the understory had been burned but pine trees had remained. Black Spruce (*Picea mariana*), shrubs, and mosses are found at the lake margin, while the upper slope has only a few small shrubs between the pines.

AL5 – Black Spruce-moss, Black Spruce-birch, and Black Spruce-alder forests. These three forests have spruce trees which remained after the fire. The Black Spruce-moss is near the lake margin; the Black Spruce-birch forest is on Wallace Island; and the Black Spruce-alder forest is near a shallow pond which drains into the main lake.

AL6 – *Sphagnum* hummocks. The hummocks were covered with Labrador Tea (*Ledum groenlandicum*). This site is near the lake margin with new pine growth up-slope where the forest had been burned.

AL7 – creek margin with willow. The willows and grasses are on the flood plain of a small creek. The adjacent area is sandy.

AL8 – deadfalls near temporary standing water. This area, near the airstrip, has pine deadfalls, and some mosses on the sand near the water.

AL9—under bark. The bark of Black Spruce deadfalls (killed by the fire) was stripped to catch ground beetles. The area is on coarse sand.

METHODS

Like the Bistcho Lake study (Shpeley 1988), beetles were collected both by visual searching and pan trapping. The efficacy of these methods was determined both in terms of the number of taxa and number of individuals collected.

To assess the community composition of the habitats, I classified the preferences of the species in terms of moisture and time of activity. Based on statements by Bousquet (1987), Hilchie (1985), Lindroth (1961-1969), Lindroth and Ball (1969), my observations, and anecdotal evidence, I recognized eleven ecological types. These types of ground beetles are as follows:

A. Hygrophile-psammophile/ Diurnal
Beetles that live along lake shores and streams close to the water, on sand, and that are active in bright sunlight. I believe that these beetles have a high moisture requirement, but further evidence is needed.

B. Hygrophile/ Diurnal
Beetles living on wet soil that is clay, peat, or a mixture of these, with or without sand, and that are active in sunlight.

C. Hygrophile/ Nocturnal
As above, but active at night.

D. Mesophile-hygrophile/ Nocturnal
Beetles whose atmospheric moisture requirement seems to be less than true hygrophiles and live in less open areas. They are active at night.

E. Mesophile/ Nocturnal
Beetles found principally in forests, where during the day, they are protected from direct sunlight; they live in leaf litter and are active at night.

F. Mesophile-xerophile/ Nocturnal
Beetles found principally in forests in association with leaf litter, but on drier types of soil. They are active at night.

G. Xerophile-mesophile/ Nocturnal
Beetles found in quite dry places in forests, such as on moraine soils, living under stones, etc. They are active at night.

H. Xerophile/ Nocturnal
Beetles found in dry places: in fields, openings in forests, or open forests. They are active at night.

I. Xerophile/ Diurnal
As for H, but active in daylight.

J. Xerophile-psammophile/ Diurnal
As for H and I, but with a preference for sand, and they are active in daylight.

K. Eurytopic/ Nocturnal
Beetles without clear habitat preferences but they are active at night.

L. Unclassified
Not classified because of a lack of suitable material.

RESULTS AND DISCUSSION

Collecting Methods

A total of 1080 specimens representing 20 genera and 53 species of ground beetles were collected at the Andrew Lake study area (Tables 1 and 2). Although the number of specimens taken by pantrapping was more than twice the number taken by searching, the two methods were similar in terms of the number of taxa. The methods were complementary in that each produced species that the other did not (11 species by searching; 9 species by trapping; Tables 1 and 2). Habitat 3 was intensively sampled by both methods, producing 34 of the 53 species. Trapping and searching produced 31 and 29 species respectively of these 34 species.

Comparisons with Collections from Bistcho Lake

At Bistcho Lake, 33 of the 46 species (71.8%) were taken from single habitats. At Andrew Lake, only 23 of the 53 species (43.4%) were taken from single habitats. The forest fire may have had some effect on the distribution of the Andrew Lake species, since more than half of them (56.6%) were collected in more than one habitat. Also, the Andrew

Table 1. Systematic list of ground beetle species collected at Andrew Lake, Alberta, 10-18 June 1988.

Species	Numbers caught by:		Habitats (AL)								
	pan traps	searching	1	2	3	4	5	6	7	8	9
Cicindela limbata hyperborea LeConte	35	1	-	X	-	-	-	-	-	-	-
Cicindela longilabris Say	39	7	-	-	X	-	-	-	-	-	-
Cicindela tranquebarica Herbst	13	1	-	X	X	-	-	-	-	-	-
Trachypachus holmbergi Mannerheim	6	3	-	-	X	X	X	-	-	-	-
Carabus taedatus Fabricius	7	2	-	-	X	-	-	-	-	X	-
Carabus chamissonis Fischer von Waldheim	3	4	-	-	-	X	X	X	-	-	-
Notiophilus semistriatus Say	5	1	-	-	X	-	-	-	-	-	-
Notiophilus borealis Harris	3	3	-	-	X	X	X	X	-	-	-
Elaphrus americanus Dejean	-	10	X	-	-	-	-	-	-	-	-
Dyschirius hiemalis Bousquet	7	2	-	-	-	X	-	X	-	-	-
Miscodera arctica Paykull	1	1	-	-	X	-	-	-	-	-	-
Trechus apicalis Motschulsky	-	6	-	-	X	-	-	-	X	-	-
Bembidion levettei Casey	-	17	X	-	-	-	-	-	-	-	-
Bembidion carinula Chaudoir	2	57	X	X	-	-	-	-	-	-	-
Bembidion grapei Gyllenhal	-	2	-	-	-	-	-	-	-	X	-
Bembidion nigripes Kirby	-	10	X	-	-	-	-	-	-	-	-
Bembidion versicolor LeConte	-	4	-	-	-	-	-	-	-	X	-
Bembidion mutatum Gemminger & Harold	3	4	-	-	X	-	-	-	-	X	-
Bembidion morulum LeConte	1	1	-	-	-	X	X	-	-	-	-
Bembidion transparens Gebler	1	-	-	X	-	-	-	-	-	-	-
Tachyta angulata Casey	-	9	-	-	-	-	-	X	-	-	X
Pterostichus lucublandus Say	3	-	-	X	X	X	-	-	-	-	-
Pterostichus adstrictus Eschscholtz	23	24	-	X	X	X	-	-	-	-	-
Pterostichus punctatissimus Randall	6	4	-	-	-	X	X	X	X	-	-
Pterostichus haematopus Dejean	20	11	-	-	X	X	X	-	-	-	-
Calathus ingratus Dejean	18	12	-	-	X	X	-	X	X	-	-
Agonum retractum LeConte	-	5	-	-	X	-	-	-	-	-	-
Agonum gratiosum Mannerheim	4	7	-	X	X	X	X	-	X	X	-
Agonum cupreum Dejean	-	1	X	-	-	-	-	-	-	-	-
Agonum corvus LeConte	-	1	X	-	-	-	-	-	-	-	-
Agonum affine Kirby	2	-	-	-	X	X	-	-	-	-	-
Platynus decentis Say	2	3	-	-	X	-	X	-	-	-	-
Amara hyperborea Dejean	176	33	-	-	X	X	X	X	-	-	-
Amara apricaria Paykull	-	1	-	-	-	-	X	-	-	-	-
Amara schwarzi Hayward	6	-	-	X	X	-	-	-	-	-	-
Amara discors Kirby	2	-	-	-	X	-	-	-	-	-	-
Amara pseudobrunnea Lindroth	1	13	-	-	X	-	X	-	-	-	-
Amara patruelis Kirby	1	-	-	X	-	-	-	-	-	-	-
Amara laevipennis Kirby	54	6	-	X	X	X	X	X	-	-	-
Amara lunicollis group sp?	1	-	-	X	-	-	-	-	-	-	-

cont.

Table 1. cont.

Amara lunicollis Schiodte	6	1	-	X	X	-	-	-	-	-	-
Amara littoralis Mannerheim	1	-	-	-	X	-	-	-	-	-	-
Harpalus laticeps LeConte	3	5	-	-	X	-	-	-	-	-	-
Harpalus egregius Casey	6	6	-	-	X	-	-	-	-	-	-
Harpalus somnulentus Dejean	1	1	-	-	X	-	-	X	-	-	-
Harpalus fuliginosus Duftschmid	22	12	-	X	X	-	-	X	-	-	-
Harpalus opacipennis Haldeman	27	4	-	X	X	-	-	-	-	-	-
Trichocellus cognatus Gyllenhal	1	3	-	-	X	-	-	-	-	-	-
Trichocellus mannerheimi Sahlberg	2	9	-	-	X	X	-	X	-	-	-
Stenolophus fuliginosus Dejean	1	-	-	-	-	X	-	-	-	-	-
Metabletus americanus Dejean	193	18	X	X	X	X	-	-	-	-	-
Cymindis cribricollis Dejean	17	3	-	-	X	-	-	-	-	X	X
Cymindis unicolor Kirby	10	11	-	X	X	X	-	-	-	X	X
Total:	751	329									

Table 2. Habitat preference of ground beetle species collected at Andrew Lake, Alberta, 10-18 June 1988.

Species	Numbers caught by:		Habitats (AL)								
	pan traps	searching	1	2	3	4	5	6	7	8	9
Elaphrus americanus Dejean	-	10	X	-	-	-	-	-	-	-	-
Bembidion levettei Casey	-	17	X	-	-	-	-	-	-	-	-
Bembidion nigripes Kirby	-	10	X	-	-	-	-	-	-	-	-
Agonum cupreum Dejean	-	1	X	-	-	-	-	-	-	-	-
Agonum corvus LeConte	-	1	X	-	-	-	-	-	-	-	-
Bembidion carinula Chaudoir	2	57	X	X	-	-	-	-	-	-	-
Metabletus americanus Dejean	193	18	X	X	X	X	-	-	-	-	-
Cicindela limbata hyperborea LeConte	35	1	-	X	-	-	-	-	-	-	-
Bembidion transparens Gebler	1	-	-	X	-	-	-	-	-	-	-
Amara patruelis Kirby	1	-	-	X	-	-	-	-	-	-	-
Amara lunicollis group sp?	1	-	-	X	-	-	-	-	-	-	-
Cicindela tranquebarica Herbst	13	1	-	X	X	-	-	-	-	-	-
Amara schwarzi Hayward	6	-	-	X	X	-	-	-	-	-	-
Amara lunicollis Schiodte	6	1	-	X	X	-	-	-	-	-	-
Harpalus opacipennis Haldeman	27	4	-	X	X	-	-	-	-	-	-
Harpalus fuliginosus Duftschmid	22	12	-	X	X	-	-	X	-	-	-
Pterostichus lucublandus Say	3	-	-	X	X	X	-	-	-	-	-
Pterostichus adstrictus Eschscholtz	23	24	-	X	X	X	-	-	-	-	-
Cymindis unicolor Kirby	10	11	-	X	X	X	-	-	-	X	X
Agonum gratiosum Mannerheim	4	7	-	X	X	X	X	-	X	X	-

Table 2. cont.

Amara laevipennis Kirby	54	6	-	X	X	X	X	X	-	-	-
Cicindela longilabris Say	39	7	-	-	X	-	-	-	-	-	-
Notiophilus semistriatus Say	5	1	-	-	X	-	-	-	-	-	-
Miscodera arctica Paykull	1	1	-	-	X	-	-	-	-	-	-
Agonum retractum LeConte	-	5	-	-	X	-	-	-	-	-	-
Amara discors Kirby	2	-	-	-	X	-	-	-	-	-	-
Amara littoralis Mannerheim	1	-	-	-	X	-	-	-	-	-	-
Harpalus laticeps LeConte	3	5	-	-	X	-	-	-	-	-	-
Harpalus egregius Casey	6	6	-	-	X	-	-	-	-	-	-
Trichocellus cognatus Gyllenhal	1	3	-	-	X	-	-	-	-	-	-
Platynus decentis Say	2	3	-	-	X	-	X	-	-	-	-
Amara pseudobrunnea Lindroth	1	13	-	-	X	-	X	-	-	-	-
Harpalus somnulentus Dejean	1	1	-	-	X	-	-	X	-	-	-
Trechus apicalis Motschulsky	-	6	-	-	X	-	-	-	X	-	-
Carabus taedatus Fabricius	7	2	-	-	X	-	-	-	-	X	-
Bembidion mutatum Gemminger & Harold	3	4	-	-	X	-	-	-	-	X	-
Cymindis cribricollis Dejean	17	3	-	-	X	-	-	-	-	X	X
Agonum affine Kirby	2	-	-	-	X	X	-	-	-	-	-
Trichocellus mannerheimi Sahlberg	2	9	-	-	X	X	-	X	-	-	-
Calathus ingratus Dejean	18	12	-	-	X	X	-	X	X	-	-
Trachypachus holmbergi Mannerheim	6	3	-	-	X	X	X	-	-	-	-
Pterostichus haematopus Dejean	20	11	-	-	X	X	X	-	-	-	-
Notiophilus borealis Harris	3	3	-	-	X	X	X	X	-	-	-
Amara hyperborea Dejean	176	33	-	-	X	X	X	X	-	-	-
Stenolophus fuliginosus Dejean	1	-	-	-	-	X	-	-	-	-	-
Dyschirius hiemalis Bousquet	7	2	-	-	-	X	-	X	-	-	-
Bembidion monilum LeConte	1	1	-	-	-	X	X	-	-	-	-
Carabus chamissonis Fischer von Waldheim	3	4	-	-	-	X	X	X	-	-	-
Pterostichus punctatissimus Randall	6	4	-	-	-	X	X	X	X	-	-
Amara apricaria Paykull	-	1	-	-	-	-	X	-	-	-	-
Tachyta angulata Casey	-	9	-	-	-	-	-	X	-	-	X
Bembidion grapei Gyllenhal	-	2	-	-	-	-	-	-	-	X	-
Bembidion versicolor LeConte	-	4	-	-	-	-	-	-	-	X	-
Total:	751	329									

Lake area appeared to be rather uniform in general habitats, whereas Bistcho was more diverse. The basic ground composition may also have been a factor, as Andrew Lake is located in the Precambrian shield.

Table 3 shows 60% more specimens were collected at Andrew Lake than at Bistcho Lake, though the magnitude of this difference is not reflected in the number of genera (2 more) or species (7 more). Of particular note is the number of genera and species collected by both methods at each of the study areas. At Bistcho Lake, only 8 of the 18 genera (44.4%) and 14 of the 46 species (30.5%) were collected by both methods. However, at Andrew Lake, 16 of the 20 genera (80%) and 33 of the 53 species (62.3%) were collected by both methods. Once again, these figures are the result of the higher percentage of species at Andrew Lake (56.6%) being found in more than one habitat, while at Bistcho Lake multiple habitat species were only 28.2%.

Collections of ground beetles at Bistcho and Andrew Lakes produced a total of 24 genera. Fourteen genera are shared between the 2 areas (Table 4). Of the 24 genera, three more should be found at Bistcho Lake, and one more at Andrew Lake, which could bring the total to 18 shared genera (Table 4, a). The remaining 6 genera may or may not be found at the two study areas (Table 4, b). There may also be other ground beetle genera present which were not collected at either site.

A total of 74 species was collected, but only 25 are shared by both study areas. This low number may be the result of the two study areas being in different geological regions.

Moisture Preference and Activity Pattern

Table 5 is a species list of ground beetles collected at Andrew Lake arranged by moisture preference-activity categories. Table 6 provides data about moisture preference-activity pattern frequency in each habitat. To facilitate comparisons, categories A-D are grouped as more hygrophile; F-J, as more xerophile. Categories E, K and L are not grouped.

In habitat 1, hygrophilous species dominate, and in habitat 7, mesophiles predominate. The overall high frequency (in habitats 2-6 and 8-9) of the more xerophilous taxa is indicative of the generally dry conditions in the boreal forest at Andrew Lake. Only in habitats 1 and 7 did hygrophilous or mesophilous taxa predominate. Absence of mesophiles from habitats 1, 2 and 8 probably reflects an absence of leaf litter (i.e., suitable ground cover), at these sites. The higher frequency of mesophiles in habitat 7 and 9 might be a sampling artifact, as only a few species were collected at each of these sites.

Table 7 summarizes data about activity patterns of adult ground beetles in relation to habitat. Overall, 26.5% of the species are diurnal, or day-active. In habitats 1 and 2, these species are relatively more frequent. The beach and adjacent area of these habitats lack suitable ground cover with which nocturnal species are usually associated.

Species Richness in Relation to Habitat

The sequence of habitats from the least to most species rich is as follows: 9- 7- (1,8)- 6- 5- 2- 4- 3. Considering the slight differences in richness between 6&5 and 2&4, the sequence can be simplified to: 9- 7- (1,8)- (6,5)- (2,4)- 3.

I expected fewer species to be found in the burned sites (2-5, 8 and 9). The high species richness might indicate enough time has elapsed since the fire for re-settlement of the affected areas. Alternatively, the burn might not have destroyed all of the ground beetle inhabitants. The largest number of species was collected in habitat 3. As mentioned above, this probably is a result of the intensive collecting in this one habitat.

It was expected that the burned sites would show a preponderance of xerophilous species, as the ground cover would have been greatly reduced: this was found to be true. In habitat 8, with the largest percentage of xerophiles, they accounted for 71.5% of the species, well above the overall value of 54.7%. In habitat 4, with the fewest xerophilous species in a burned habitat, the value (44.5%) is below the overall value. Habitat 1, which was not burned, had the highest percentage of hygrophilous (71.4%) and diurnal (71.4%) species.

In summary, the Andrew Lake area had a slightly more species rich assemblage of ground beetles

Table 3. Numbers of ground beetles collected at Bistcho and Andrew Lakes, Alberta.

	Bistcho Lake Number of:			Andrew Lake Number of:		
Collected by:	genera	species	specimens	genera	species	specimens
searching	13	33	334	19	44	329
pan trapping	15	27	277	17	42	751
both methods	8	14	423	16	33	996
area total	18	46	611	20	53	1080

Table 4. Genera of ground beetles collected at Bistcho and Andrew Lakes, Alberta.

Genus	Bistcho	Andrew
Cicindela Linnaeus	a	X
Trachypachus Motschulsky	a	X
Carabus Linnaeus	X	X
Pelophila LeConte	X	b
Nebria Latreille	X	b
Notiophilus Dumeril	X	X
Elaphrus Fabricius	X	X
Loricera Latreille	X	a
Dyshirius Bonelli	X	X
Miscodera Eschscholtz	b	X
Trechus Clairville	X	X
Bembidion Latreille	X	X
Tachyta Kirby	b	X
Patrobus Dejean	X	b
Pterostichus Bonelli	X	X
Calathus Bonelli	X	X
Agonum Bonelli	X	X
Platynus Bonelli	X	X
Amara Bonelli	a	X
Harpalus Latreille	X	X
Trichocellus Ganglbauer	X	X
Stenolophus Stephens	b	X
Metabletus Schmidt-Goebel	X	X
Cymindis Latreille	X	X

X - collected at study site

a - should be present, though not collected in 1987 or 1988

b - possibly present, if correct habitat can be found at study site

Table 5. Ground beetle species of Andrew Lake, Alberta classified by moisture preference and time of activity of adults.

A. Hygrophile-psamophile/ Diurnal

Bembidion levettei Casey
Bembidion carinula Chaudoir

B. Hygrophile/ Diurnal

Elaphrus americanus Dejean
Bembidion nigripes Kirby
Bembidion versicolor LeConte
Bembidion transparens Gebler

C. Hygrophile/ Nocturnal

Dyschirius hiemalis Bousquet
Agonum corvus LeConte
Agonum affine Kirby
Stenolophus fuliginosus Dejean

D. Mesophile-hygrophile/ Nocturnal

Agonum gratiosum Mannerheim
Platynus decentis Say

E. Mesophile/ Nocturnal

Trechus apicalis Motschulsky
Bembidion monulum LeConte
Tachyta angulata Casey
Pterostichus punctatissimus Randall
Pterostichus haematopus Dejean
Agonum retractum LeConte
Trichocellus cognatus Gyllenhal
Trichocellus mannerheimi Sahlberg

F. Mesophile-xerophile/ Nocturnal

Amara hyperborea Dejean
Harpalus laticeps LeConte
Harpalus egregius Casey
Harpalus fuliginosus Duftschmid

G. Xerophile-mesophile/ Nocturnal

Carabus taedatus Fabricius
Carabus chamissonis Fischer von Waldheim
Calathus ingratus Dejean
Agonum cupreum Dejean
Amara laevipennis Kirby
Amara lunicollis Schiodte

Amara littoralis Mannerheim
Harpalus opacipennis Haldeman

H. Xerophile/ Nocturnal

Miscodera arctica Paykull
Bembidion grapei Gyllenhal
Amara apricaria Paykull
Amara schwarzi Hayward
Amara discors Kirby
Amara pseudobrunnea Lindroth
Amara patruelis Kirby
Cymindis cribricollis Dejean
Cymindis unicolor Kirby

I. Xerophile/ Diurnal

Cicindela longilabris Say
Cicindela tranquebarica Herbst
Trachypachus holmbergi Mannerheim
Notiophilus semistriatus Say
Notiophilus borealis Harris
Bembidion mutatum Gemminger & Harold
Metabletus americanus Dejean

J. Xerophile-psammophile/ Diurnal

Cicindela limbata hyperborea LeConte

K. Eurytopic/ Nocturnal

Pterostichus lucublandus Say
Pterostichus adstrictus Eschscholtz
Harpalus somnulentus Dejean

L. Un-classified

Amara lunicollis group species?

Table 6. Moisture preferences of ground beetle species by habitat at Andrew Lake, Alberta

Preference	Overall	Habitats								
		AL1	AL2	AL3	AL4	AL5	AL6	AL7	AL8	AL9
Hygrophilous[1]	22.6[3]	71.4	18.7	8.8	22.2	16.7	9.1	25.0	28.5	
Mesophilous	15.1			14.7	22.2	25.0	27.3	50.0		33.0
Xerophilous[2]	54.7	28.6	62.5	67.7	44.5	58.3	54.5	25.0	71.5	67.0
Eurytopic	5.7		12.5	8.8	11.1		9.1			
Unclassified	1.9		6.3							

[1] - includes categories A-D
[2] - includes categories F-J
[3] - all numbers are percent occurence

Table 7. Number of species of ground beetles collected in each habitat at Andrew Lake, Alberta classified by activity pattern.

Habitat	Activity Pattern			
	Nocturnal	Diurnal	% Diurnal	Total
AL1	2	5	71.4	7
AL2	11	5	31.2	16
AL3	27	7	20.5	34
AL4	17	3	15.0	20
AL5	10	2	16.7	12
AL6	10	1	9.1	11
AL7	4	0	0.0	4
AL8	6	1	14.3	7
AL9	3	0	0.0	3
Total	39	14	26.5	53

than did Bistcho Lake. This may be the result of the fire, the overall dry conditions, or the study areas being in different geological regions. If the 1979 forest fire had an effect on the ground beetle fauna, the 1988 collecting trip indicates that it was a positive one.

ACKNOWLEDGMENTS

I thank both A.T. Finnamore and P.H.R Stepney of the Provincial Museum of Alberta for the invitation to participate in the Andrew Lake expedition. I also thank G.E. Ball, Department of Entomology, University of Alberta for his review and constructive comments regarding the original manuscript. Lastly, I thank the Department of Entomology for permitting me the time to participate in this study, both in the field and in the lab.

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Figure 1. A pre-burn view (1970) of Andrew Lake showing mature Jack Pine forest on a granitic outcrop of the Canadian Shield. (photo courtesy of Otto Höhn).

Figure 2. Setting deep water nets in Jackfish channel. On the opposite shore, a burned Jack Pine stand with scattered patches of surviving trees.

Figure 3. Seining for small fish in an inflowing stream bordered by willow and alder shrubs atop a levee.

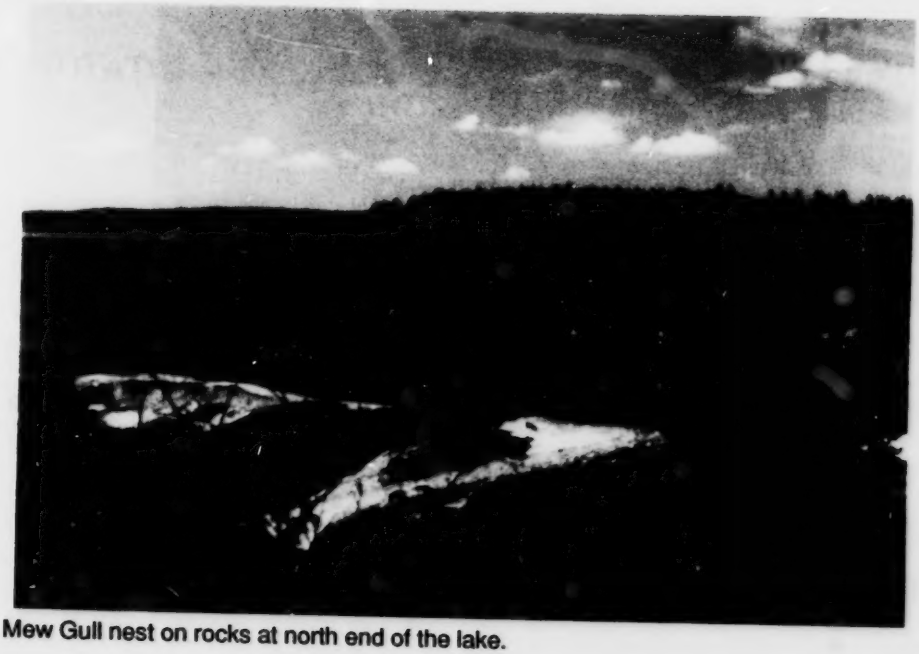

Figure 4. Mew Gull nest on rocks at north end of the lake.

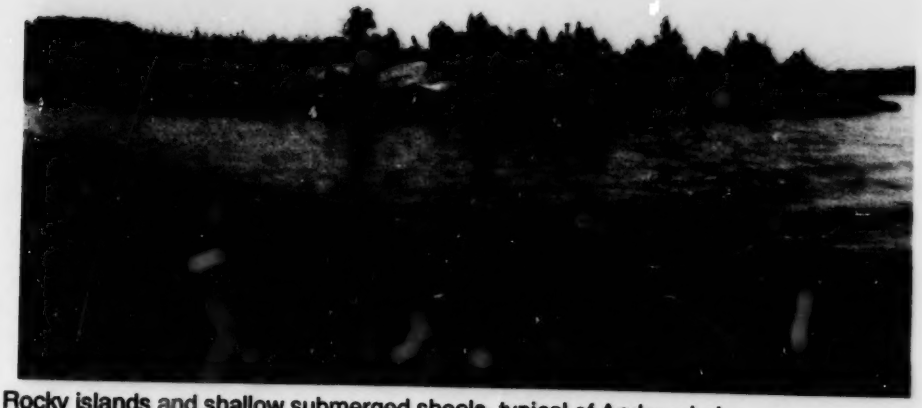

Figure 5. Rocky islands and shallow submerged shoals, typical of Andrew Lake, are composed of bedrock more resistant to erosion than the surrounding lake bed.

Figure 6. Unburned Jack Pines growing on the thin soil of a granite outcrop at the south end of the lake.

Figure 7. A Jack Pine/Alder stand regenerating on thin glacial till.

ANNOTATED LIST OF THE BUTTERFLIES (LEPIDOPTERA) OF ANDREW LAKE

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The following is an annotated list of the butterflies collected at Andrew Lake in June 1988. Because of the short duration of the expedition, many of the 53 species that were expected in the area (Scott 1986) were not flying and hence not collected. This is supported by our acquisition of eight species collected at Andrew Lake, and twelve species at Bistcho Lake, (Thormin 1988) but only two that were common to both areas. All eighteen species should occur in both regions.

Information on distribution and larval food plants was obtained from Klots (1960), Hooper (1973), Howe (1975), Scott (1986) and Tilden and Smith (1986). Food plants are given for the whole distribution of each butterfly, and thus may include plants that do not occur in Alberta.

Family Hesperiidae

Erynnis persius (Scudder) **Hairy Dusky Wing**

This nearctic species has two populations. The eastern population is found from southern Quebec and Ontario south to North Carolina and from the eastern seaboard west to Wisconsin, the western ranges from Alaska south to Arizona and east to western Manitoba. In Alberta it is found in open woodlands throughout the province. Food plants include *Salix* (Willow), *Populus* (Poplar), and various Leguminosae.

Family Papilionidae

Papilio glaucus canadensis Rothschild & Jordan. **Tiger Swallowtail**

A nearctic species that is distributed across North America from Newfoundland to central Alaska and south to northeastern Colorado. In Alberta it is found flying in or near *Populus* forests. Food plant is usually *Populus* although it also feeds on *Prunus* (Cherry), *Betula* (Birch), *Sorbus* (Mountain Ash), *Salix* (Willow), *Liriodenron* (Tulip Tree), *Fraxinus* (Ash), *Tilia* (Basswood) and *Malus* (Apple).

Family Lycaenidae

Callophrys augustus augustinus Westwood. **Brown Elfin**

The Brown Elfin is found in North America from Alaska to Newfoundland south of the tundra, and south to northern Georgia and the mountains of northwestern Mexico. In Alberta it flies in open coniferous and mixed forests. The subspecies *augustinus* seems to be restricted to *Vaccinium* sp. (Blueberry) for its larval food plant.

Celastrina argiolus lucia (Kirby) **Spring Azure**

This is a nearctic species found throughout North America south of the tundra, and south through central America to Panama. The subspecies *lucia*, which is found in Alberta, flies in open poplar and mixed forests, brushy areas and hedgerows. The larvae feed on *Cornus* (Dogwood), *Spiraea* (Meadowsweet), *Vaccinium* and many other species.

Family Nymphalidae

Polygonia progne progne (Cramer) **Dark-gray Comma**

The Dark-gray Comma is found from Newfoundland west to central British Columbia and south to Arkansas and central California. This includes the species *P. silenus* which is now classified as a subspecies of *progne* (Scott 1986). The subspecies *progne* flies throughout Alberta in poplar woods and shrubby areas. The larvae feed primarily on *Ribes* spp., mainly Gooseberry.

Boloria freija freija Thunberg. **Zigzag Fritillary**

This is a North American species found in the tundra and boreal forest from Newfoundland to Alaska and southern Ellesmere Island south to Wisconsin and northern New Mexico in the mountains. In Alberta the subspecies *freija* flies in grassy areas near *Picea* (spruce) and *Pinus* (pine) forests and in dry bogs. Larval food plants include *Vaccinium cespitosum* (Dwarf Bilberry), *Arctostaphylos uva-ursi* (Bearberry) and *Rubus chamaemorus* (Cloudberry).

Family Satyridae

Erebia discoidalis (Kirby) **Red-disk Alpine**

The Red-disk Alpine is a north American species distributed from central Quebec to central Alaska south from the edge of the tundra to northern Michigan and northern Montana. It flies in open dry grasslands and moist prairie. The larvae feed on *Poa* spp. (Bluegrass).

Oeneis jutta jutta (Huebner) **Forest Arctic**

This is a holarctic species with a North American distribution in the boreal forest from Newfoundland to Alaska and to Michigan and Colorado. It flies in spruce bogs and grassy pine forests. The subspecies *jutta* flies throughout Alberta, except in the prairies and is found throughout most of Canada as well as Scandinavia and Asia. Food plants include species of *Eriophorum* (Cotton Grass), *Carex* (Sedge) and *Juncus* (Rush).

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THE FISH AND HERPETOFAUNA OF ANDREW LAKE

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INTRODUCTION

In June of 1988 ten staff of the Provincial Museum of Alberta visited Andrew Lake in northeastern Alberta in the second of a series of multidisciplinary collecting trips to remote regions of the province (see McGillivray and Hastings 1988, Steinhilber 1988). Although my primary purpose on this expedition was to collect ichthyological and herpetological specimens for the Provincial Museum, I also gathered some basic biophysical data to augment the specimen records.

A number of reports have been prepared on lake characteristics and fisheries resources of the Kazan upland area which includes Andrew Lake, (Rhude 1975, Renewable Resources Consulting Services 1976, MacDonald and Fudge 1979) but an ichthyological and limnological survey by Turner (1967) appears to be the only detailed study previously conducted on Andrew Lake. Fish species records reported by Paetz and Nelson (1970) from this locality are based primarily on University of Alberta Department of Zoology museum collections, student theses, as well as reports and collections from Alberta Fish and Wildlife staff. Previous herpetofaunal surveys of the Andrew Lake region have been conducted by Preble (1908), Harper (1931), and Wallis and Wershler (1984).

METHODS

Specimen and Data Collection

Fish and amphibian collecting sites in or near Andrew Lake are shown in Figure 1. Fish were collected with a variety of sampling tools including gill nets, one 3.75 cm (1.25 ") stretch mesh 4.57 m x 1.82 m (15' x 6') multifilament nylon net, and one 1.90 cm (3/4") stretch mesh 7.62 m x 1.22 m (25' x 4') monofilament net, a beach seine, minnow traps (Gee Traps), dip nets, and hook and line. Much of the length, weight, age and stomach content data was acquired from fish caught by sport fishermen. In these cases, measurements were taken, the cleithra and gut were removed for later analysis and the carcass was returned to the collector. Specimens to be retained were killed in 35% alcohol if necessary and fixed in 10% buffered formalin. After 1 to 3 weeks (depending on the size of specimen) they were rinsed in tap water and placed in 70% ethanol for permanent storage in the research collection at the Provincial Museum of Alberta.

Where possible, when the complete specimen was not retained, the cleithrum was dissected out of the pectoral girdle following the procedure reported by Casselman (1978). The number of annuli were counted under reflected light with the cleithra on a black background. All cleithra, whether used for age determinations or not, were numbered and incorporated into the ichthyology collection.

The gut tract was removed from many of the fish which were not retained. The excised material was fixed and stored in 10% formalin until laboratory analyses could be conducted. After several months the stomachs were rinsed in tap water and the contents removed, sorted and identified.

The first left branchial arch was dissected out of all retained Ciscos. The number of gill rakers was determined by pinning the arch onto black cardboard to provide contrast and then counting the gill rakers under 20x magnification.

All amphibians were caught by hand. Some collecting was done after dark with a flashlight but this proved no more successful than during the day. Specimens were fixed in 10% buffered formalin, rinsed in tap water and stored in 65% ethanol.

Dissolved oxygen concentrations were measured in the field with a Chemetrics model 0-12 dissolved oxygen colorimetric test kit. pH was also measured in the field using "Hanna Instruments pH Electronic Paper" accurate to $\pm$ 0.2 pH. All measurements were taken at the surface of the water. Bottom samples were collected with a modified Peterson dredge. Basic substrate and vegetation information

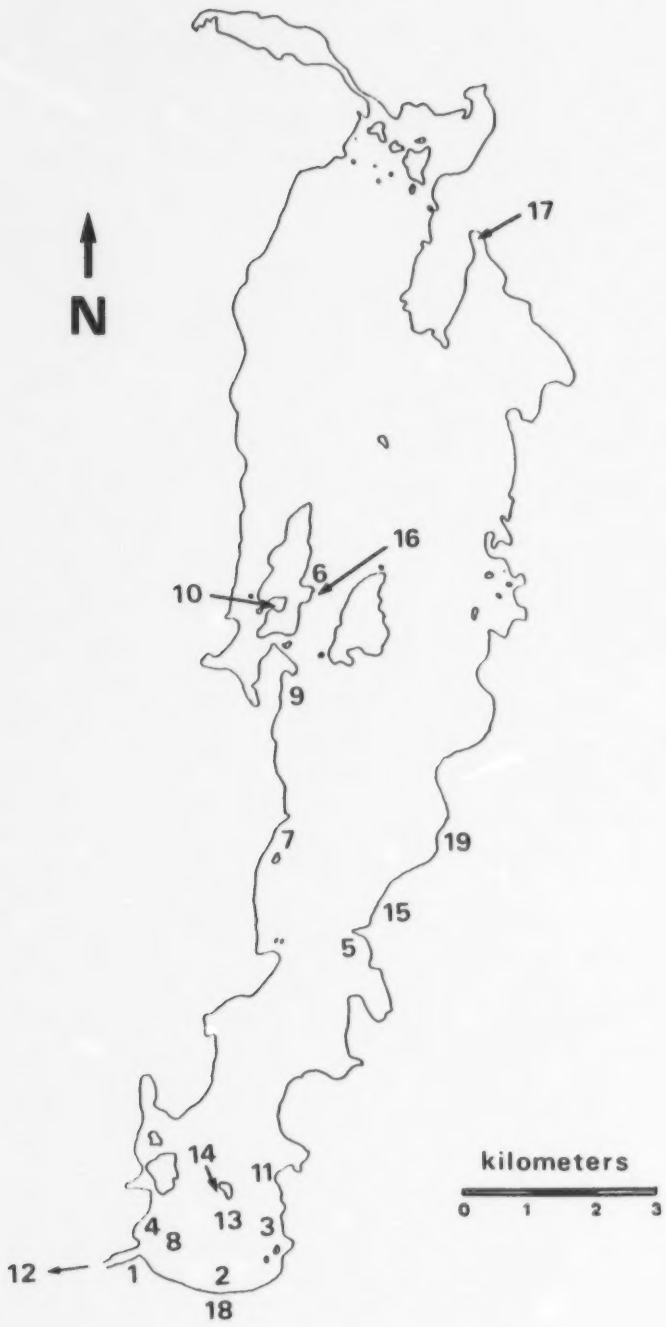

Figure 1. Fish and amphibian collecting sites, Andrew Lake.

was acquired from these samples but no in depth analysis of the bottom composition was conducted.

RESULTS

Study Area

Andrew Lake is situated in the exposed Precambrian rocks of the Kazan uplands of northeastern Alberta (Fig. 2). It is part of the Slave River drainage basin although the exact route of drainage from the lake is difficult to determine. Turner (1967) speculated that the flow may be into Charles Lake and then via the Tethul and Taltson Rivers to Great Slave Lake (see inset, Fig. 2).

Andrew Lake covers 53.6 km^2 and has a shoreline of 108.6 kilometers. It is 18.8 kilometers long and has a maximum width of 5.3 kilometers. The maximum depth is 37 meters and the mean depth is 7.9 meters (Turner 1967). Bottom contours are given in Fig. 3 and the depth distribution, as derived from Fig. 3 is shown in Table 1. Temperature, dissolved oxygen and pH readings taken during this study are shown in Table 2. Secchi disc transparency readings taken near site 3 were 5.0 m. Based on morphological and limnological data collected in 1966 and 1967, Turner (1967) classified Andrew Lake as mesotrophic. This general and somewhat arbitrary classification is intermediate between oligotrophic or deep, clear, generally nutrient poor lakes and eutrophic or shallow, turbid and nutrient rich lakes. The maximum depth, water clarity, and development of a thermocline in Andrew Lake suggest oligotrophy although the large proportion of the lake less than 6 meters in depth (55%), is more typical of eutrophic lakes, hence the mesotrophic designation.

Aquatic vegetation through most of the lake is sparse or absent. A littoral zone is virtually non-existent along much of the shoreline. The shallow channel and large bay at the northwestern end of the lake are exceptions. In the main body of the lake, extensive sand and gravel flats dominate the substrate composition in the 0-4 m depth range. Many smaller areas with a bottom consisting of boulders and rubble, often encrusted with algae, are also common at this depth. In these areas, little foundation for rooted plants is available. Where the rock is overlain by silt, sparse clumps of Quillwort (*Isoetes echinospora*) can be found. In deeper areas the bottom consists largely of sand, clay and marl with no rooted vegetation (Turner 1967).

The shallow, slow moving, streams and channels flowing into and out of the lake contains Duckweed (*Potamogeton* spp.), River Horsetail (*Equisetum fluviatile*), Wild Calla (*Calla palustris*), Pondlily (*Nuphar variegatum*), Water Milfoil (*Mirophyllum spicatum*) and several species of Sedges (*Carex* spp.) including *C. aquatilus*. Detailed plant species accounts are found elsewhere in this volume (see Hastings and Ellis).

Table 3 lists the lower vertebrate species, known or expected to occur, in Andrew Lake and the surrounding area (general species distribution map by McPhail and Lindsey (1970), Scott and Crossman (1973) and Cook (1984) were also consulted when compiling this list). An asterisk (*) indicates those species encountered during this study.

Species Status

Because only a small proportion of the fish observed or captured during this expedition were collected, the "number of specimens retained" does not always clearly indicate the relative abundance of the various species. A subjective ranking of species abundance has therefore been adopted to include all collected specimens and observations of species and their numbers. Abundances are ranked as follows: *abundant* - seen or captured regularly in large numbers; *common* - seen or captured regularly in small numbers; *uncommon* - encountered on a few occasions; *rare* - encountered only once or twice. This scale can, of course, be affected by collecting and observing effort, collecting methods, and the habits of the animals themselves.

SPECIES ACCOUNTS

Lake Trout (*Salvelinus namaycush*) - 2 specimens retained

This common species was captured regularly at sites throughout the lake (1, 2, 3, 4, 5, 6, 7, 9, 14) in 1.5 to 3.0 m of water over rocky or sandy substrates with little or no vegetation. Although Lake Trout typically move to deeper, cooler regions of the lake as the water warms during the summer, the temperature recorded at the surface during the study period (11^{o}-12^{o}C) was very close to the

Figure 2. Location of Andrew Lake study area showing suggested route of drainage from the lake.

Figure 3. Bottom contours of Andrew Lake (reproduced from Turner [1967]).

Table 1.Depth distribution of Andrew Lake as determined from Figure 2.

Depth Range	% of Total
0-3 m	32.2
3-6 m	22.5
6-9 m	9.3
9-37 m	36.0

Table 2. Temperature, dissolved O_2 and pH of water samples taken at the surface of Andrew Lake, 11-18 June 1988.

Site	Temperature (°C)	O_2 (mg/l)	pH
1	11	8	6.8
3	13	9	
12	20	9	

Table 3. Lower vertebrate species reported from Andrew Lake and surrounding area.

Fish
Lake Trout (*Salvelinus namaycush*)*
Cisco (*Coregonus artedii*)*
Lake Whitefish (*Coregonus clupeaformis*)*
Northern Pike (*Esox lucius*)*
Lake Chub (*Couesius plumbeus*)*
Longnose Sucker (*Catostomus catostomus*)
White Sucker (*Catostomus commersoni*)*
Burbot (*Lota lota*)
Trout-Perch (*Percopsis omiscomaycus*)*
Ninespine Stickleback (*Pungitius pungitius*)*
Walleye (*Stizostedion vitreum*)
Slimy Sculpin (*Cottus cognatus*)*

Amphibians
Canadian Toad (*Bufo americanus hemiophrys*)
Wood Frog (*Rana sylvatica*)*
Striped Chorus Frog (*Pseudacris triseriata*)
Northern Leopard Frog (*Rana pipiens*)

Reptiles
Common Garter Snake (*Thamnophis sirtalis*)

* encountered during this study.

preferred temperature for this species (10°C) (Scott & Crossman 1973).

The Lake Trout is native only to northern North America within a range loosely defined by the limits of the Pleistocene glaciation (McPhail & Lindsey 1970). In Alberta it is known from the Slave, Peace, Beaver, upper Athabasca, North Saskatchewan and South Saskatchewan drainages (Paetz & Nelson 1970). Turner found Lake Trout to be common in his 1967 survey of Andrew Lake.

Fork length and weight measurements were taken for 19 of the 21 individuals we encountered. The median and range of this data is presented in Appendix 1. Although 1 specimen weighed 10.8 kg (24 lbs) the average size was in the 1-2 kg range.

Cisco (*Coregonus artedii*) - 37 specimens retained

This abundant species was found, often in large numbers, at 2 sampling sites (4 and 6) in 1.8 to 2.0 m of water. The bottom at site 4 was primarily composed of large algae-encrusted rocks with no rooted vegetation. Site 6 was in a large, shallow, sandy bottomed, bay with very little rooted vegetation. Schools of several hundred individuals were encountered in these areas on a number of occasions.

Cisco, or Lake Herring, are found only in North America from the Great Lakes region and Mississippi drainage northwest to the Mackenzie drainage in the Northwest Territories (Scott & Crossman 1973). In Alberta, this species is native to the Slave, Athabasca, and Beaver River drainages and has been introduced into the Bow River system in southern Alberta (Paetz & Nelson 1970). Paetz & Nelson also report it from the Peace River system but McPhail & Lindsey (1970) claim it has not been found in the Peace or Liard River drainages. Cisco have been previously reported from Andrew Lake by Turner (1967) who found them in the stomach contents of Lake Trout.

Fork length and total length measurements for the Cisco which were retained are shown in Table 3. The maximum length achieved by native Cisco is widely variable between lakes. In Alberta, the largest individual, as reported by Paetz & Nelson (1970) was from Myers Lake and measured 305 mm (12 inches) in fork length. In some lakes (e.g., Gordon Lake, Northwest Territories) mature individuals have been found which were less than 150 mm (6 inches) standard length (McPhail & Lindsey 1970). It has been suggested (Paetz 1980) that the productivity of a lake influences the size attained by mature Ciscos. The largest individual collected was 121 mm in total length. This small size together with the appearance of the gonads in several randomly selected individuals suggests all of the specimens we encountered were immature.

The Cisco exhibits a great deal of morphological variability throughout its range. Rather than describing numerous subspecies, McPhail & Lindsey (1970) have suggested the use of the term "*Coregonus artedii* complex" to collectively describe those forms which differ in some characters but share other basic morphological features. One of the main criteria used to differentiate members of the *C. artedii* complex forms from other morphologically similar Ciscos is gill raker number. Typically *C. artedii* typically has about 40-55 gill rakers on the first branchial arch (McPhail and Lindsey 1970; Paetz 1980) although extremes of 38-64 have been reported from various Canadian localities (Scott & Crossman 1973). Gill raker counts from the Cisco we collected at Andrew Lake are presented in Figure 4. Although tending toward lower numbers [$\bar{x}$ = 42.4 (range 38-49)] the values are indicative of individuals in the *C. artedii* complex.

In our survey, as in the study by Turner (1967), Cisco were found to be an important forage fish for Lake Trout. The fork lengths of all Cisco recovered from the stomach contents of Lake Trout were in the 100-111 mm range.

Lake Whitefish (*Coregonus clupeaformis*) - 2 specimens retained

This common species was encountered at 5 sites (1, 3, 6, 8, 16) in water depths ranging from 2.0 m to 5.5 m. The lake bottom at the 5 sites varied from a uniform sand and small gravel substrate with little vegetation to a rocky bottom with no rooted vegetation. Site 16 was on a transition zone where a shallow, sandy area dropped off rapidly to a deeper, rocky region.

The Lake Whitefish is widely distributed throughout northern North America (McPhail & Lindsey 1970, Scott & Crossman 1973). It is native to most northern and central Alberta drainages and is found in the Bow and Oldman systems although most populations in these watersheds may not be

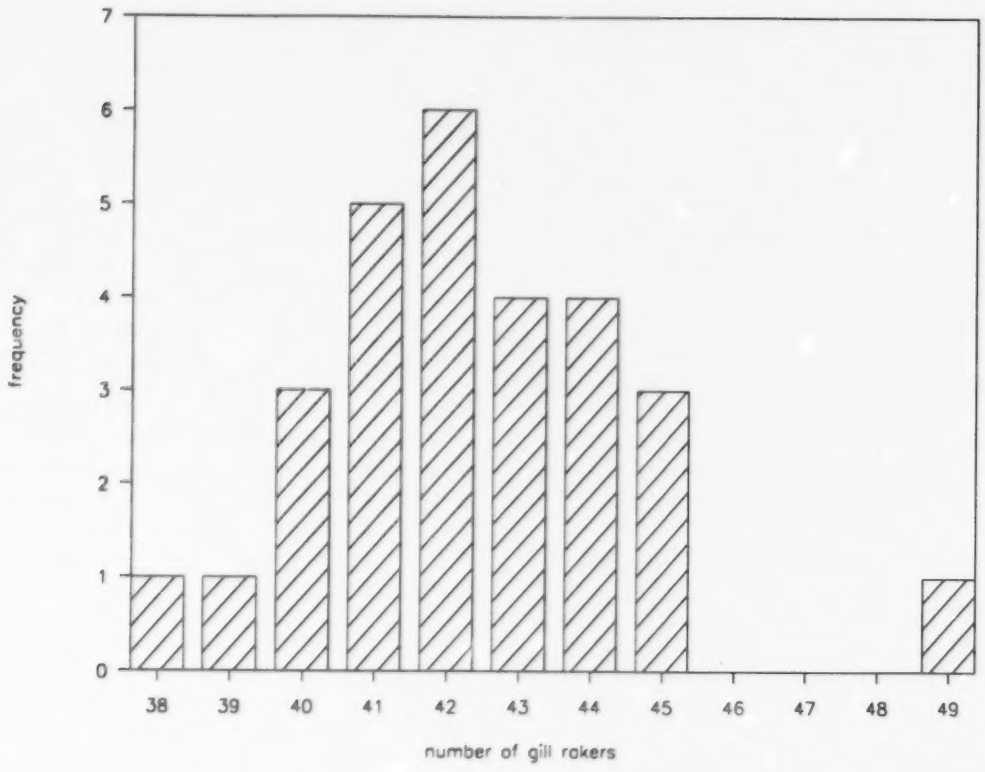

Figure 4. Gill raker counts from Cisco collected at Andrew Lake, 1988.

native (Paetz & Nelson 1970). Turner reported Lake Whitefish in his 1967 study of Andrew Lake.

Fork lengths and weights for the 6 Lake Whitefish encountered on this expedition are shown in Appendix 1.

As with the Cisco, and many other coregonids, morphological variability is great in the Lake Whitefish. A "*Coregonus clupeaformis* complex" has been suggested (McPhail & Lindsey 1970) to collectively describe this difficult group of whitefish. Modal gill raker counts have been used in an attempt to differentiate the various taxa within this group but many taxonomic problems still exist.

Northern Pike (*Esox lucius*) - 2 specimens retained

This common species was encountered regularly but in small numbers at 10 sites throughout the lake (1, 3, 4, 5, 10, 12, 14, 15, 16, and 17). During the study period, sport fishermen reported limited and somewhat sporadic or localized success for this species. Although some individuals were netted in 2.0 m to 3.0 m of water over rocky substrates (site 3) the majority of pike were found in shallow (0.2 m to 1.0 m) areas with a sand and detritus substrate and some rooted vegetation. The outflow channel at the extreme southwest corner of the lake (sites 1 and 12) exhibits many of these characteristics and has been locally named "Jackfish Alley". A small, shallow stream entering the lake at site 15 contained numerous pike in the 0.5 kg to 2.0 kg range. *Carex aquatilus*, *Calla palustris* and *Equisetum* sp. grew abundantly in this area. The shallow channel and bay at the northwest end of the lake is the largest region of suitable Pike habitat in the lake. We did not retain specimens from this area, however.

The Northern Pike has a circumpolar distribution in fresh waters of the northern hemisphere. It is

found throughout most of Canada except the maritime provinces and is restricted to the northernmost part of British Columbia (Scott & Crossman 1973). In Alberta, it inhabits almost all major drainage systems (Paetz & Nelson 1970). Turner reported pike in his 1967 survey of Andrew Lake.

Fork lengths and weights for the 20 pike examined during this study are shown in Appendix 1. Two individuals were immature (119 and 121 mm fork length) the others ranged from 508 mm to 870 mm fork length and 0.7 kg to 2.6 kg in fresh weight.

Cleithra were dissected from 17 adults and age determinations were made following the procedure reported by Casselman (1978, 1980). Age classes 5 and 6 predominated in this sample. One individual was found to be 7 years old and three were 4 years of age.

Lake Chub (*Couesius plumbeus*) - 40 specimens retained

This abundant species was encountered at 4 sites on the lake (1, 4, 6 and 7) and in a small creek entering the lake at site 15. Specimens were collected over a variety of substrates in water depths ranging from 0.3 m to 2.0 m. Small numbers (10-15) were regularly gill netted in 1.5 m to 2.0 m of water over large algae-encrusted rocks and boulders. Large numbers (several hundred) were seined and observed in shallow water (<0.5 m) over coarse sand and fine gravel in a slow moving creek.

The Lake Chub is found throughout most of Canada and portions of the northern United States (Scott & Crossman 1973). In Alberta it is widespread in all major drainage systems (Paetz & Nelson 1970). Turner reported Lake Chub in his 1967 survey of Andrew Lake.

Fork lengths and total lengths of all Lake Chub encountered are shown in Appendix 1. Although the largest fork length measured was 90 mm, specimens with a total length in excess of 200 mm have been reported by Scott & Crossman (1973) from Mattagoni Lake in Quebec. In Alberta, this species attains a maximum fork length of about 127 mm (5 inches) (Paetz & Nelson 1970).

Three Lake Chub were identified in the stomach contents of one Lake Trout we examined. The extent to which Lake Chub are utilized as a food source by larger predatory fish in Andrew Lake is uncertain. It appears, from our sampling, however, that Cisco and Ninespine Stickleback are chosen more frequently by the Lake Trout and Northern Pike.

White Sucker (*Catostomus commersoni*) - 1 specimen retained

Only 1 White Sucker was captured or observed during the study period making its status rare by the definitions given earlier. The specimen, an immature measuring 74 mm fork length, was seined in a small stream at site 15. At the point of capture, the stream is about 5 m wide, 0.5 m deep and slow moving with a bottom consisting largely of coarse sand and gravel. Rooted vegetation is predominantly *Calla palustris* and *Carex aquatilus*.

This North American species is found from the MacKenzie River east to the Atlantic coast and south to northern Oklahoma, Georgia and New Mexico. It appears to be absent from the barren grounds of northern Canada (McPhail & Lindsey 1970). In Alberta it is known from all major drainage systems (Paetz & Nelson 1970). Turner (1967) did not report the White Sucker in his survey of Andrew Lake but did note the occurrence of its congener, the Longnose Sucker (*Catostomus catostomus*).

Trout-perch (*Percopsis omiscomaycus*) - 4 specimens retained

This uncommon species was gill netted at sites 4 and 7 in 0.8-2.0 m of water over a rocky substrate with little or no vegetation. At site 7, sparse patches of *Isoetes echinospora* were found where the rocks and boulders gave way to patches of gravel in a sand matrix.

This species is widely distributed throughout central and northern North America but is less common south of the Great Lakes (Scott & Crossman 1973). In Alberta it is found in rivers and lakes throughout most of the major drainage systems (Paetz & Nelson 1970). Turner reported this species in his 1967 study of Andrew Lake.

Fork lengths and total lengths are shown in Appendix 1 for the 4 Trout-Perch collected. Magnusson and Smith (1963) working on the Lower Red Lake, Minnesota found females to be slightly larger

than males at all age classes. The largest Canadian specimens reported by Scott & Crossman (1973) were from Lake Ontario where individuals reached 152 mm in total length.

No Trout-Perch were identified from the stomach contents of any of the Lake Trout, Northern Pike or Lake Whitefish examined. Other studies (Lawler 1954, Magnusson & Smith 1963, McPhail & Lindsey 1970) have found Trout-Perch to be an important forage fish for a wide range of predatory species.

Ninespine Stickleback (*Pungitius pungitius*) - 40 specimens retained

This abundant species was captured regularly in shallow water (0.1 m to 0.5 m) in areas with a sandy or silty bottom and some rooted vegetation, most commonly *Carex aquatilus* (sites 1 and 6). Large numbers were observed often in several centimeters of water under overhanging bog laurel (*Kalmia polifolia*) branches along the channel at site 1.

Ninespine Stickleback are widely distributed throughout the northern hemisphere in both marine and fresh water environments although spawning apparently occurs only in fresh water (Nelson 1968). In Canada, it is found from the Atlantic Coast to central and northern Alberta, and northeastern British Columbia, north to the Arctic Ocean (Scott & Crossman 1973). In Alberta it is known from localities on the Petitot, Hay, Slave, Peace, Athabasca and Beaver drainages (Paetz & Nelson 1970). Turner did not report Ninespine Stickleback in his 1967 survey of Andrew Lake.

Fork lengths and total lengths from 43 Ninespine Stickleback measured are shown in Appendix 1. Jones and Hynes (1950) in a study in England found the growth rate of the species to be very rapid during the first year of life, slowing considerably in later years. They found total lengths of up to 46 mm in first year fish and up to 55 mm in 3rd year fish (average life span 3.5 years). In Alberta, the maximum fork length reported is about 61.5 mm (2.5 inches) from Pine Lake in Wood Buffalo National Park (Paetz & Nelson 1970).

Ninespine Stickleback were found regularly in the stomach contents of Lake Trout and Northern Pike from Andrew Lake. Our sampling suggests that Sticklebacks are second only to Cisco in importance as a forage species in this lake.

Slimy Sculpin (*Cottus cognatus*) - 11 specimens retained

This common species was collected in shallow waters (0.5 m to 1.0 m) over gravel or sandy substrates at sites 1, 6 & 15. Ten of the 11 specimens were collected in 0.5 m of water over large gravel in a coarse sand matrix with no rooted vegetation. One specimen was collected in a shallow (0.5 m), slow moving stream with a coarse sand and gravel bottom in close proximity to dense patches of *Carex aquatilus*. Although this species is commonly found in rocky shallows in northern lakes (Scott & Crossman 1973) it has been reported from depths as great as 80 m (260 ft) in Lake Superior (Dryer 1966).

The Slimy Sculpin is found throughout northern North America and northeastern Siberia. In Canada it occurs in favorable habitats from New Brunswick and Labrador to Saskatchewan, northern Alberta and some coastal British Columbia drainages (Scott & Crossman 1973). It occurs in Northern Alberta in the Petitot, Hay, Slave, Peace, Athabasca and Beaver River drainages (Paetz & Nelson 1970). The Slimy Sculpin was reported by Turner (1967) in his study of Andrew Lake.

Total lengths of the Slimy Sculpins collected on this expedition are shown in Appendix 1. Specimens as large as 120 mm standard length have been reported from other Canadian localities (McPhail & Lindsey 1970). The largest specimens known from Alberta are approximately 79 mm (3.5 inches) in total length (Paetz & Nelson 1970).

One Slimy Sculpin was identified from the stomach contents of a Lake Trout collected in this study. Studies in other Canadian waters (Rawson 1961, Van Oosten & Deason 1938, Dryer et. al 1965) large predatory fish such as Lake Trout & Northern Pike regularly use the Slimy Sculpin as a food source.

Wood Frog (*Rana sylvatica*) - 3 specimens retained

Although only 3 specimens were collected, this species was probably more common than our sampling suggests. In the evening, numerous individuals could be heard calling from marshy areas off the lake. Two specimens were collected from a small pond largely overgrown with willows at site 18. One individual was captured along a small stream at site 19.

The Wood Frog occurs throughout most of Canada in wooded areas. Its range extends north to the treeline, following the wooded MacKenzie valley to the arctic coast. It is absent from prairie regions and southern British Columbia (Cook 1984).

In some Wood Frog populations, especially in the northern and western parts of its range, a color phase can be found in which a white dorso-medial stripe is common. One of the 3 specimens we collected had this stripe.

DISCUSSION

Twelve species of fish, 4 amphibians and 1 reptile species have been reported from Andrew Lake and the surrounding area (Preble 1908, Turner 1967, Paetz & Nelson 1970, Wallis & Wershler 1984, Cook 1984). Of these, 9 fish and 1 amphibian were encountered during this study. Because the duration of the study period was only 8 days, factors such as sampling effort (hours) and time of the year certainly affected the number of species we observed. Sampling methods (net size and placement and trap placement) also would have influenced our success. The lack of specific amphibian and reptile collecting equipment (i.e., pit traps and funnel traps) probably contributed to the low diversity of herpetofaunal specimens observed. Following is a brief annotated list of those species which were not observed.

Longnose Sucker (*Catostomus catostomus*)

One of the most widespread fish in northwestern North America (Scott & Crossman 1973), this species has been reported from Andrew Lake by Paetz & Nelson (1970) and Turner (1967). Gill net placement (most often near the surface in less than 5 meters of water) may have affected our success in capturing these and other bottom-dwelling species. No doubt the populations of suckers in Andrew Lake is larger than our sampling suggests.

Burbot (*Lota lota*)

This species is widespread throughout northern North America and Eurasia. It has been reported from Andrew Lake by Paetz & Nelson (1970) and Turner (1967).

Walleye (*Stizostedion vitreum*)

The Walleye is a common inhabitant of many northern Alberta lakes. It appears, however, to be extremely rare in Andrew Lake. Paetz & Nelson (1970) report it from this locality but Turner found no evidence of Walleye in his 1967 survey. He speculated that the report of this species, from commercial fishing records, was a mistake and that the Walleye may have come from another lake in the same general area. The owner of the Andrew Lake Fishing lodge, however, (Glen Wettlaufer pers. comm.) said that he had seen 1 Walleye taken from the lake in the past 4 years. The details of this record are uncertain.

Canadian Toad (*Bufo americanus hemiophrys*)

This subspecies of the American Toad (*Bufo americanus americanus*) is common in the aspen parkland and boreal forest of central Canada (Cook 1984). It has been reported as far north as Fort Smith, N.W.T. (Preble 1908). This toad typically frequents ponds, sloughs, roadside ditches, streams and the margins of larger lakes (Stebbins 1966).

Northern Leopard Frog (*Rana pipiens*)

The Leopard Frog is the most widely distributed amphibian in North America ranging from the Northwest Territories to Panama (Stebbins 1966). The northern limit of its range extends north of Andrew Lake to the Fort Smith - Great Slave Lake area in the Northwest Territories and Great Slave Lake (Cook 1984). In the spring and early summer, it can often be found along the margins of larger lakes (W. Roberts, pers. comm.) but by midsummer it typically disperses into moist upland areas (Cook 1984).

Striped Chorus Frog (*Pseudacris triseriata*)

Two subspecies of the Striped Chorus Frog are currently recognized in Canada. The Midland Chorus Frog (*P.t. triseriata*) is found in Quebec, Ontario and Newfoundland. The Boreal Chorus Frog (*P.t. maculata*) ranges from Ontario to B.C. and north into the MacKenzie valley in the N.W.T. (Cook 1984). Although it typically inhabits shallow pools in open, prairie regions it will use deeper permanent water bodies in densely wooded areas (Stebbins 1966).

Common Garter Snake (*Thamnophis sirtalis*)

This species is the most widely distributed North American reptile and the most abundant and widespread snake in Canada (Stebbins 1966, Cook 1984). The subspecies occurring in Alberta (*T.s. parietalis*) ranges throughout most of the central and northern part of the province and into the Northwest Territories near Fort Smith (Cook 1984). It is typically found near water which it readily enters if threatened.

STOMACH CONTENT ANALYSES

The stomach contents of 17 Lake Trout, 10 Northern Pike and 6 Lake Whitefish were examined and the findings summarized in Appendix 2. Although the analyses are largely qualitative, the number of individuals recovered of each species or group is indicated to give some idea of its relative importance to each predatory species. No attempt has been made to estimate the percentage of the total volume of the stomach contents contributed by each prey item.

Lake Trout

The stomachs of 4 individuals contained Lake Whitefish, the remains of which were in excess of 400 mm in length. Exact lengths were impossible to determine because the samples were partially digested. Other identifiable fish species were Cisco, Ninespine Stickleback, Lake Chub and Slimy Sculpin. A wide variety of invertebrate specimens were also recovered. Numerically, Chironomid larva (Chironomidae) and Water Boatmen (Corixidae) predominated. Three individuals had consumed large numbers of beetles (Coleoptera) many of which were terrestrial species. The abundance of these and other terrestrial invertebrates in the diet of many of the Lake Trout sampled suggests that these fish are feeding at or near the surface at this time of the year.

Lake Whitefish

The stomach of 1 Lake Whitefish contained 310 caddisfly pupae (Trichoptera) in their cases. Although adult Caddisflies are terrestrial, the larvae are aquatic. They cannot swim and are therefore restricted to the benthic region of a waterbody (Pennak 1978). Gastropods (snails), bivalves (small clams), aquatic beetles (Dytiscidae) and fine gravels were also found in the Whitefish stomachs. The great preponderance of bottom dwelling species recovered, even from this very small sample, suggests that whitefish were feeding primarily on the bottom during the study period. None was caught by hook and line (all were gill netted) or seen at or near the surface by any members of the expedition.

Northern Pike

The Pike stomachs examined were either empty or contained very little material. In those which were not empty, Ninespine Stickleback were the most common identifiable prey species. Small numbers of chironomid larva, Caddisfly larva and leeches were also recovered.

AGE DETERMINATION

Scales have been used traditionally to determine age and growth rates in fish (Creaser 1926, Van Oosten 1929). However, recent work has suggested that they may not be a good indication of age or growth rate because: (1) there is wide variability in the size of scales even from the same part of the body; (2) scales grow more slowly and even stop growing as the fish ages; and (3) the growth rate of scales deviates more from that of the body than do other calcified structures (Casselman 1979). A variety of other calcified structures (e.g., fin rays, otoliths, vertebra) have therefore been used by fisheries scientists for age and growth assessment. The cleithrum, an element in the pectoral girdle, has been used successfully to age members of the Pike Family (Esocidae) (Casselman 1978).

In our study, cleithra were dissected from 16 Lake Trout, 4 Lake Whitefish and 18 Northern Pike which were not to be retained as museum specimens. Figure 5 is a photograph of a cleithrum from a Northern Pike showing the annuli, the location of the origin and the various components of this structure. The annuli which are seen as a wide translucent zone followed by a narrower opaque zone represent 1 year of growth of the cleithrum. The degree of translucency of the tissue deposited in the cleithrum is directly related to the degree of mineralization of the tissue and inversely related to food consumption. Therefore as food consumption decreases, the tissue deposited becomes increasingly translucent. These periods of high and low nutrient intake tend to cycle on a yearly (seasonal) basis thus allowing the age of the fish to be determined by counting the number of opaque and translucent bands.

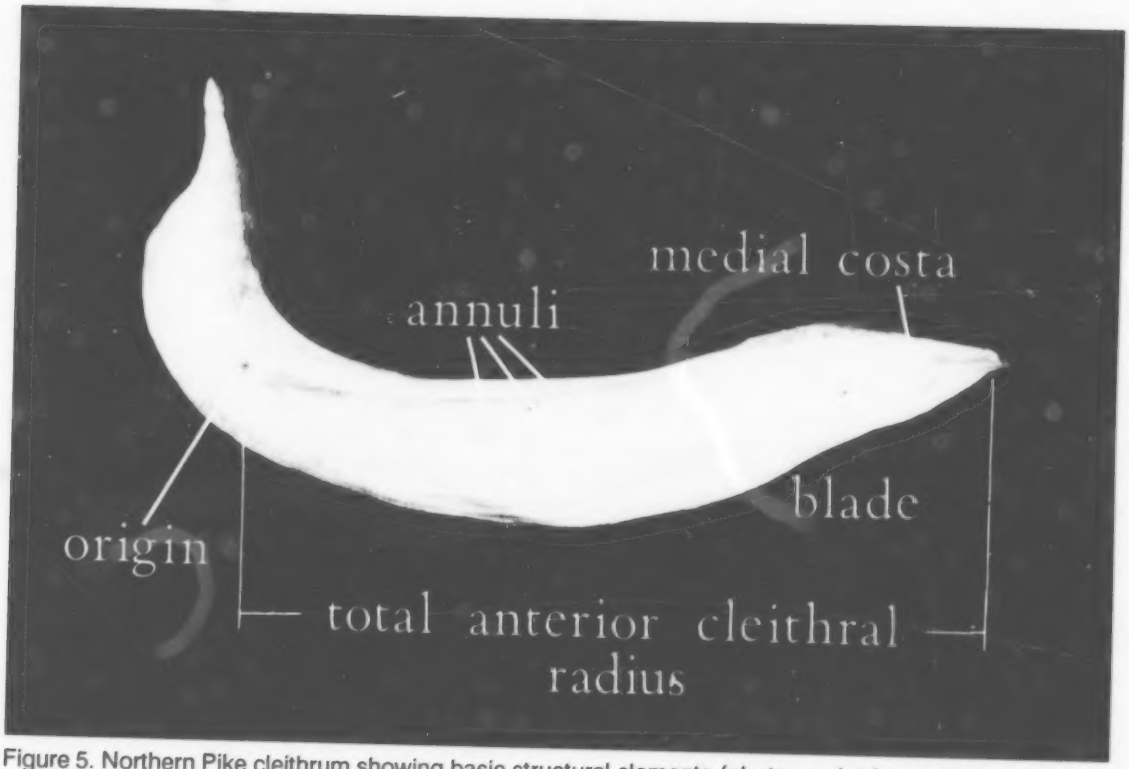

Figure 5. Northern Pike cleithrum showing basic structural elements (photographed under reflected light).

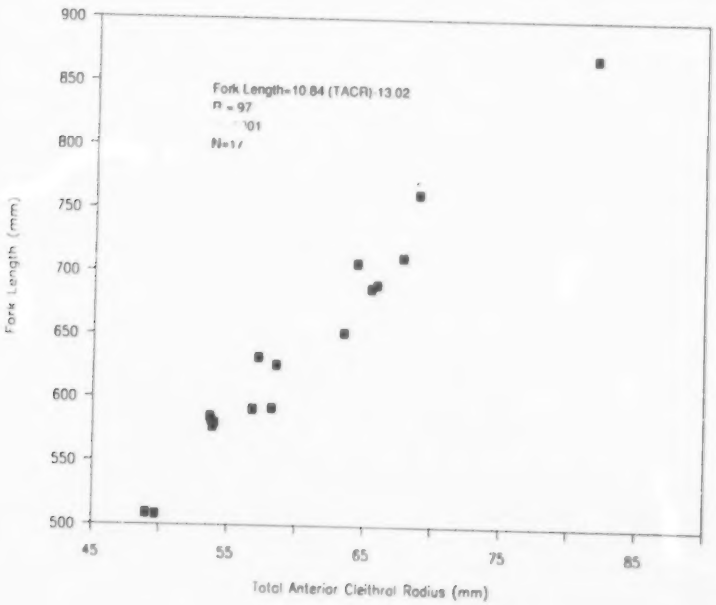

Figure 6. Relationship between fork length and total anterior cleithral radius for Andrew Lake Northern Pike.

A strong linear correlation has been found to exist between the length of the cleithrum and body length in esocids (Casselman 1978). The total anterior cleithral radius (TACR), or the linear distance from the origin to the point where the anterior tip of the blade intersects the medial costa (see Figure 5), is the measurement used to calculate this relationship. We found a significant ($P < .0001$) correlation between fork length and TACR for Andrew Lake Northern Pike (Figure 6). The regression equation Fork Length (mm) = 10.84 (TACR) - 13.02 is useful for estimating or "back-calculating" body lengths at time of capture from information contained from the cleithrum alone. In addition, previous rates of growth, body condition and nutritional level can be estimated from examination of this structure (Casselman 1979).

Although we dissected the cleithrum out of a number of Lake Trout and Lake Whitefish it appears that this structure has not previously been used to age these species. Examination of the otoliths would have been a method for aging these fish but these structures were not retained. The validation work done by Casselman (1978) on Northern Pike and his very detailed description of the procedures for determining ages via the cleithral method gave us the confidence to pursue this method for the Northern Pike.

CONCLUSION

Nine species of fish and 1 species of amphibian were collected over an 8-day period between 10 and 18 June 1988 in and around Andrew Lake. Due in large part to the short duration of the expedition a number of "expected" species were not encountered.

Stomach content analyses of Lake Trout, Lake Whitefish and Northern Pike suggest that during the study period Lake Trout were feeding in shallow water at or near surface, Lake Whitefish were feeding primarily on benthic material and Northern Pike were not feeding actively.

Age determinations by analysis of the cleithrum worked well for Northern Pike but could not be used for other species due to a lack of studies validating its use. The ease of removal, the ability to analyze it macroscopically even in the field, and its close correlation with increase in age makes the cleithrum a promising choice of calcified structure for aging a wide variety of fish. Its use certainly appears to merit further study.

ACKNOWLEDGMENTS

All members of the expedition, particularly Bill Weimann and Mike Luchanski assisted in the collection of specimens and specimen data. Wayne Roberts of the U. of A. Zoology Museum kindly loaned us some very important collecting equipment. Albert Finnamore and Terry Thormin of the Invertebrate Zoology program at the PMA provided invaluable assistance in the identification of insects recovered from fish stomachs. Danny Shpeley and Ed Fuller of the Entomology Department at the U. of A. identified the Carabid and Elaterid beetles. Colleen Steinhilber typed the mansucript and provided editorial assistance. Special thanks to Dr. Philip Stepney for supporting and encouraging this study.

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Appendix 1. Measurements of fish from Andrew Lake, June 1988.

Species	n	Fork Length (mm)		Total Length (mm)		Fresh Weight (kg)	
		Median	**Range**	**Median**	**Range**	**Median**	**Range**
Lake Trout	19	569.7	(443-850)	--	--	1.7	(0.7-10.8)
Cisco	37	100.0	(82-113)	110	(89-121)	--	---
Lake Whitefish	6	442.5	(312-511)	--	--	1.0	(0.7-1.6)
Northern Pike	20	591.5	(119-870)	--	--	.35	(0.01-2.6)
Lake Chub	109	33.0	(24-90)	36.0	(27-95)	--	---
White Sucker	1	74.0	--	77.0	--	--	---
Trout-Perch	4	78.5	(73-82)	85.5	(78-90)	--	---
Ninespine Stickleback	43	43.0	(34.5-48.0)	43.5	(35.0-49.0)	--	---
Slimy Sculpin	11		--	41.0	(32-67)	--	---

Appendix 2. Stomach content analysis of Lake Trout, Lake Whitefish and Northern Pike from Andrew Lake, 1988.

	No. of Specimens recovered
Lake Trout	
Vertebrates	
Cisco (*Coregonus artedii*)	8 (100-111mm F.L.)
Lake Whitefish (*Coregonus clupeaformis*)	4 (>400mm)
Ninespine Stickleback (*Pungitius pungitius*)	13
Lake Chub (*Couesius plumbeus*)	3 (86-87mm F.L.)
Slimy Sculpin (*Cottus cognatus*)	1
unidentified fish remains	42 (73% <30mm F.L.)

Appendix 2. cont.

Invertebrates	
Mollusca: Gastropoda (Snails)	2
Annelida: Hirudinea (Leeches)	1
Arthropoda: Arachnida (Spiders)	1
Malacostraca: Amphipoda (Amphipods)	20
Insecta: Ephemeroptera (Mayflies)	5
Orthoptera: Tetrigidae (Pygmy Grasshoppers)	2
Hemiptera: (Bugs)	2
Corixidae (Water Boatmen)	114
Pentatomidae (Stink Bugs)	1
Notonectidae (Backswimmers)	1
Neuroptera: Sialidae (Alder Flies): *Sialis* sp.	1
Coleoptera: Cerambycidae (Longhorn Beetles)	3
Carabidae (Ground Beetles): *Pterostichus adstrictus* (Esch.)	1
Calthus ingratus (Dej.)	1
Amara hyperborea (Dej.)	9
Harpalus laticeps (LeC.)	1
Elateridae (Click Beetles): *Ctenicera ochreipennis* (LeC.)	1
Ctenicera kendalli (Kirby)	5
Ctenicera hoppingi (Van D.)	1
Eanus decoratus (Mann.)	1
Cleridae (Checkered Beetles): *Thanasimus* sp.	1
Salpingidae (Narrow waisted Bark Beetles): *Lecontia discicollis* (LeC.)	19
Byrrhidae (Pill Beetles): *Byrrhus* sp.	6
Chrysomelidae (Leaf Beetles)	2
Cicindelidae (Tiger Beetles)	1
Trichoptera (Caddis Flies)	310
Lepidoptera (Butterflies and Moths)	1
Diptera: Tipulidae (Crane Flies)	4
Chironomidae (Midges)	162
Bibionidae (March Flies): *Bibio* sp.	24
Hymenoptera: Vespidae (Yellowjackets and Hornets): *Vespula vulgaris* (L.)	1
Symphyta (Sawflies): Cimbicidae	1
Tenthredinidae (Common Sawflies)	3
Apoidea (Bees)	1
Formicidae (Ants): *Camponotus* sp.	1
Ichneumonidae: Ichneumoninae (Ichneumons)	1

cont.

Miscellaneous

unidentified fish eggs	32 clumps (10mm dia or less)
small gravel	
unidentified plant material	15 small pieces

Lake Whitefish

Invertebrates

Mollusca:	Gastropoda (Snails)		1
	Bivalvia (Clams)		8
Arthropoda:	Malacostraca: Amphipoda (Amphipods)		4
	Insecta:	Ephemeroptera (Mayflies)	1
		Coleoptera: Dytiscidae (Predaceous Diving Beetles)	2
		Deronectes sp.	1
		Trichoptera (Caddis Flies)	310

Miscellaneous

Coarse sand and fine gravel

Northern Pike

Vertebrates

Ninespine Stickleback (*Pungitius pungitius*)	21
unidentified fish remains	8 (11-160 mm; 7 <20mm)

Invertebrates

Annelida: Hirundinea (Leeches)		3
Arthropoda: Insecta: Diptera: Chironomidae (Midges)		1
	Trichoptera (Caddis Flies)	1

Miscellaneous

unidentified fish eggs	3 clumps (<20mm dia.)
unidentified plant material	2 small pieces

BIRDS OF THE ANDREW LAKE REGION

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Distribution maps of North American birds in field guides are based, for the most part, on specimen records housed in museums. Authors of these guides are forced to assume, because of the incompleteness of specimen information, that intervening areas between records are also occupied. While this is a reasonable assumption where habitats are uniform in the middle of a species range, at range boundaries or where subspecies overlap these approximations become problematic.

Earlier, McGillivray (1988) reported on a collection of birds from Bistcho Lake in northwestern Alberta. Here we describe a collection taken at Andrew Lake in northeastern Alberta. These lakes were chosen for study because no published accounts of the birds of these regions had been undertaken previously (although see the Appendix).

Historical Accounts:

Northeastern Alberta, as defined here, is the region north of Lake Athabasca, primarily east of Wood Buffalo National Park. Geologically, this region is unique in Alberta because of the exposure of Canadian Shield rocks.

The confluence of the Peace and Athabasca Rivers at the western edge of Lake Athabasca and access from these rivers down the Slave to the Mackenzie lead to extensive exploration of the region in the late 18th and 19th centuries. In the 1760s and 1770s, Samuel Hearne recorded natural history observations from the Lake Athabasca region which were published in his journal (see Houston 1987).

The first major ornithological study in the area, documented in Fauna Boreali-Americana Part Second, the Birds (Swainson and Richardson 1831) includes observations of the interior of the *Fur-Countries* made on the first two expeditions of Sir John Franklin. In the 1860s, Hudson Bay Company officials, inspired by Robert Kennicott, became zoological collectors for Spencer Fullerton Baird of the Smithsonian Institution (Preble 1908). In 1901 Edward Preble travelled from Washington D.C. to Ft. Chipewyan and down the Slave River collecting birds and mammals for the Bureau of Biological Survey, United States Department of Agriculture. In his account of the trip (Preble 1908) he details the contributions made by a series of explorers and visitors to the region including Emile Petitot, 1862-83; Dr. A.R.C. Selwyn, Canadian Geological Survey (CGS), 1875; Dr. Robert Bell, (CGS) 1892; Warburton Pike, 1889-90; Elizabeth Taylor, 1892; J.B. Tyrrell (CGS), 1892-94; and Frank Russell (University of Iowa) 1892-94. In 1907, Preble returned with Ernest Thompson Seton primarily to collect mammals but they studied birds sufficiently to warrant a publication (Seton 1908). Francis Harper, a zoologist for the Canadian Geological Survey, made detailed observations of the fauna between Lake Athabasca and Great Slave Lake in 1914. He returned to the area in 1920 while working for the United States Biological Survey (Harper 1931). A list of birds observed along the Peace, Athabasca, Mackenzie River systems is given in Williams (1922). In the 1940s, two ornithologists, Dewey Soper (1942) and Stephen Eaton (1948), provided accounts of the birds of Wood Buffalo Park and of the Peace and Slave Rivers respectively.

There are three recent studies of the birds of the region: Nero (1963) on the birds of the Saskatchewan side of Lake Athabasca; an unpublished study "The Birds of the Lake Athabasca area, Mackenzie District, N.W.T., Alberta and Saskatchewan" by E. Otto Höhn in 1973; and Wallis and Wershler (1984) which is a survey of the flora and fauna of the Kazan upland of northeastern Alberta. The Kazan upland is a physiographic unit delimiting the shield region of northern Manitoba, Saskatchewan, northeast Alberta and much of the southern Northwest Territories.

The older studies covered the eastern part of the region accessible by canoe on rivers about 100 km to 200 km distant from Andrew Lake. The study by Wallis and Wershler (1983) included observations

from Colin and Wylie Lakes both about 40 km from Andrew Lake. Otto Höhn camped at Andrew Lake from 10 to 14 July 1970 and his list of birds encountered (Appendix) is the only historical data available from the immediate area of the lake.

STUDY AREA

Andrew Lake is cut into the precambrian rock of the Kazan Upland in northeastern Alberta (Fig. 1). The northern tip of the lake is 3 km from the Northwest Territories, while the eastern edge is within 3 km of the Saskatchewan border. The lake is approximately 18 km long, 2 to 6 km wide, and runs primarily in a north-south direction.

Numerous small islands dot the lake but are most prevalent at the ends of the lake. The largest islands are Wallace Island and an adjacent unnamed island (Fig. 2). Two channels branch off the main lake, one at the north and one at the south end. The entire shoreline, numerous islands, and the north and south channels, were surveyed in the present study.

A large fire swept through the area in 1979 leaving very little mature forest. A subsequent wind storm flattened most of the standing, burned trees. Main habitat types are: (1) burned Jack Pine (*Pinus banksiana*) forest; (2) mature island communities of Jack Pine and Black Spruce (*Picea mariana*); (3) mature Aspen Poplar (*Populus tremuloides*) communities; (4) sedge marshes mixed with willow and alder; (5) thick new growth of birch, alder, and willow; (6) open water; and (7) rocky islands with little or no vegetation. The highest diversity of habitat types is along the channels and consequently the majority of our time was spent there. Vegetation and plant community descriptions are provided elsewhere in this volume (see Hastings and Ellis, this volume).

COLLECTIONS

A map of the collecting sites is shown in Fig. 2. In the annotated listings we refer frequently to several sites: the northwest channel, the southwest channel, our tent site, the sandy area, and the lodge. The deadfall from the fire made access to the area surrounding the lake extremely difficult. Boats were used extensively to access different habitat types. In all, about 21 man-days were spent surveying the area.

SPECIES STATUS

In preparing the annotated list, besides recording the presence of a species, an effort was made to rank abundance to one of the following levels: abundant, common, fairly common, uncommon, and rare. These are arbitrary but loosely defined as follows: *abundant* - seen in large numbers in a variety of habitats every day; *common* - seen in large numbers but less widespread and not every day; *fairly common* - seen regularly but not in great numbers; *uncommon* - seen only on a few occasions or if consistently, in low numbers at one site; *rare* - seen only once or twice. Obviously, the size, taxonomic group, and "detectibility" of each species will affect its abundance on this scale. Additional comments are provided in the discussion section for those species marked with an asterisk.

RESULTS

Species Accounts

Common Loon (*Gavia immer*) - specimens 4; egg sets 3; status common: Pairs seen in all areas of lake, nests common on smaller islands.

Red-necked Grebe (*Podiceps grisegena*) - specimens 0; status rare: one individual seen 11 June in open water, southwest end of lake.

Canada Goose (*Branta canadensis*) - specimens 0; status uncommon: two flocks of 7 to 10 birds were seen near the southwest end of lake.

Mallard (*Anas platyrhynchos*) - specimens 0; status fairly common: observed and flushed from nests in southwest and northwest channels.

American Wigeon (*Anas americana*) - specimens 0; status uncommon: pairs seen in southwest channel.

Ring-necked Duck (*Aythya collaris*) - specimens 0; status rare: one female observed in southwest channel.

Lesser Scaup (*Aythya affinis*) - specimens 0; status fairly common: seen regularly in southwest and northwest channels. Two females were flushed from nests.

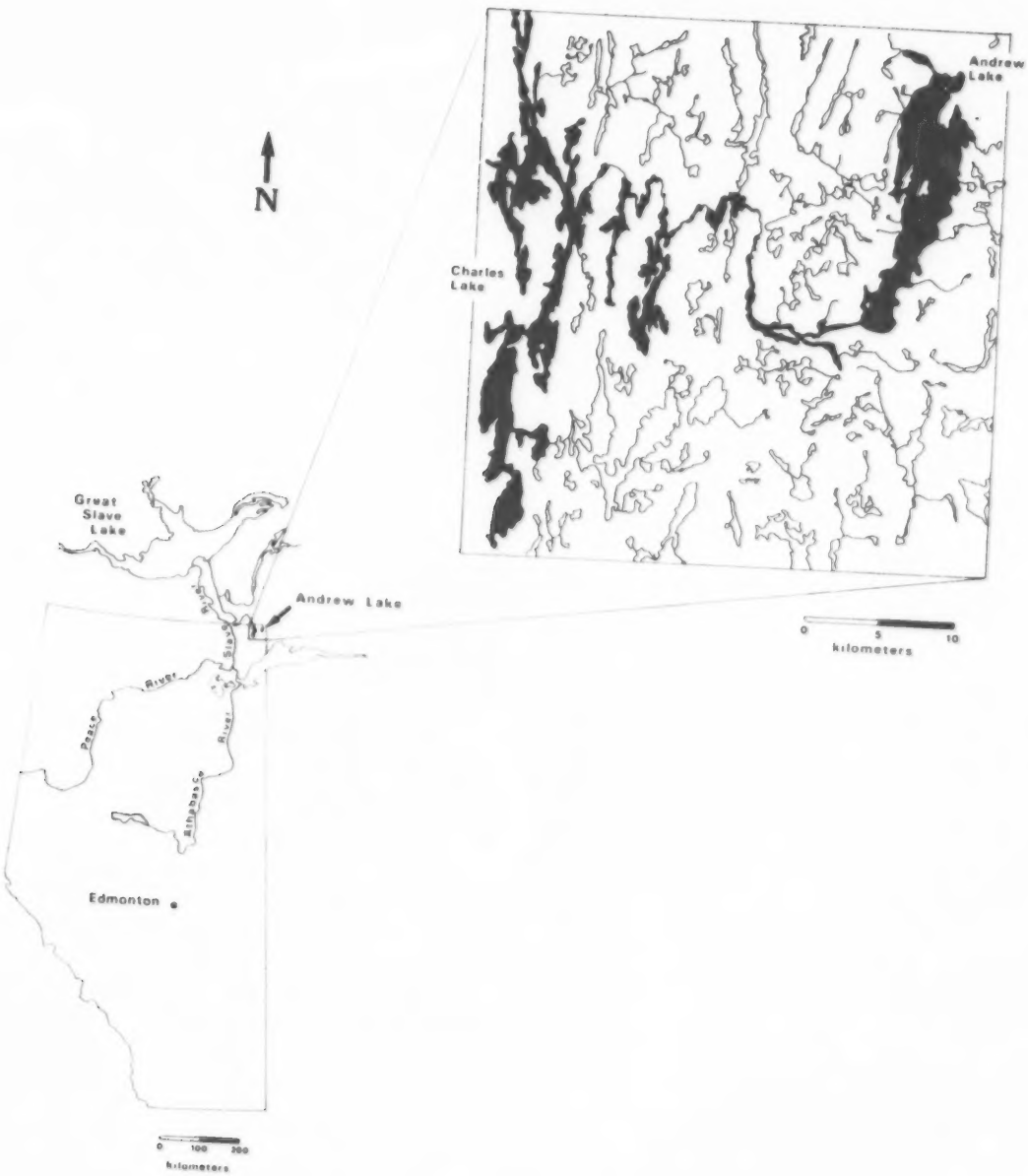

Figure 1. Location of the study area – Andrew Lake, Alberta.

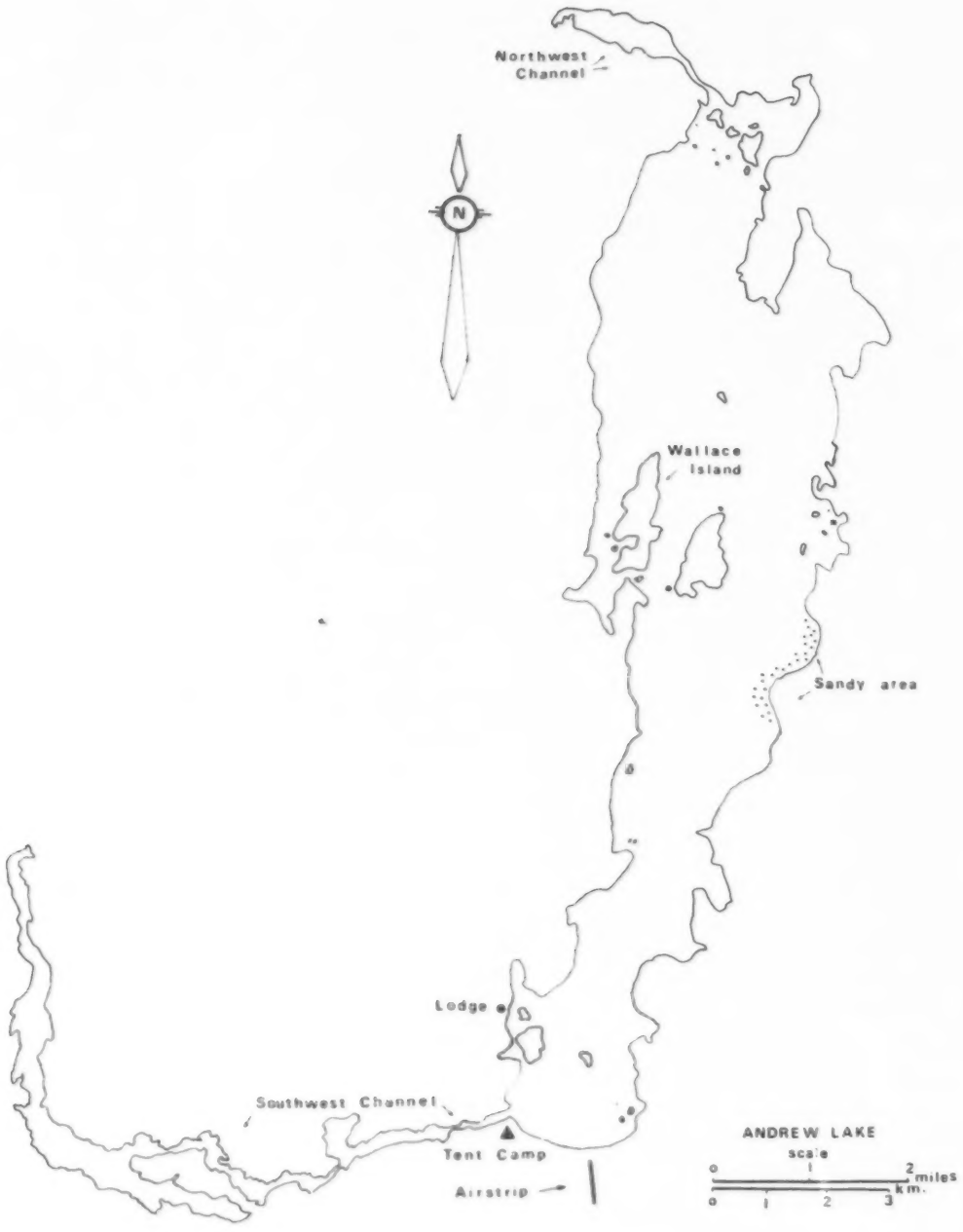

Figure 2. Detail of Andrew Lake, Alberta.

Surf Scoter (*Melanitta perspicillata*) - specimens 9; status abundant: seen in flocks of 25 to 50 birds in open water on lake.

Bufflehead (*Bucephala albeola*) - specimens 0; status fairly common: pairs seen in both southwest and northwest channels.

Common Merganser (*Mergus merganser*) - specimens 2; status fairly common: pairs noted occasionally along shoreline or islands. Nesting was suspected but not confirmed.

Red-breasted Merganser (*Mergus serrator*) - specimens 3; status fairly common: pairs sighted in southwest channel and occasionally on shoreline, one nest near lodge.

Osprey (*Pandion haliaetus*) - specimens 0; status rare: two observed or one bird seen twice, no evidence of breeding.

Bald Eagle (*Haliaeetus leucocephalus*) - specimens 0; status common: pairs with active nests at the northeastern and southeastern ends of lake.

Sharp-shinned Hawk (*Accipiter striatus*) - specimens 0; status rare: pair observed twice in northwest channel, no evidence of breeding but the pair seemed territorial.

Cooper's Hawk (*Accipiter cooperii*) - specimens 0; status rare: single bird observed along northwest channel perched in small Black Spruce.

American Kestrel (*Falco sparverius*) - specimens 0; status rare: breeding pair on eastern shore near large sand bar, nest in burned Jack Pine.

Spruce Grouse (*Dendragapus canadensis*) - specimens 6; status common: most observations in unburned areas of mainland or treed islands. One adult female collected had large brood patch.

Sora (*Porzana carolina*) - specimens 0; status uncommon: a male was heard calling several times in marshy area south end of lake.

Killdeer (*Charadrius vociferus*) - specimens 2; status uncommon: three pairs found breeding along air strip at the south end of lake. Two more pairs breeding along the sandy area, west central part of lake.

Greater Yellowlegs (*Tringa melanoleuca*) - specimens 1; status uncommon: two birds observed along the southwest channel. No evidence of breeding but birds behaved as if on territories.

Lesser Yellowlegs (*Tringa flavipes*) - specimens 1; status uncommon: birds observed in northwest and southwest channel, also along airstrip. Pairs noted but no nests found.

Spotted Sandpiper (*Actitis macularia*) - specimens 2; status fairly common: pairs observed near airstrip and the sandy area west central area of lake. No confirmed nests found.

Semipalmated Sandpiper (*Calidris pusilla*) - specimens 2; status rare: four birds seen on small rocky island south end of lake.

Parasitic Jaeger (*Stercorarius parasiticus*) - specimens 3; status uncommon: five individuals seen harassing terns on small rocky islands. No evidence of breeding found.

Mew Gull (*Larus canus*) - specimens 5; egg sets 1; status uncommon: two pairs breeding on small rocky island south end of lake, one pair breeding northeastern rocky island.

Herring Gull (*Larus argentatus*) - specimens 4; egg sets 1; status common: pairs and nests on many of the small rocky islands.

Common Tern (*Sterna hirundo*) - specimens 7; egg sets 1; status common: breeding pairs common on small rocky islands. Nests varied from patches of grass on rocks to bare rock.

Common Nighthawk (*Chordeiles minor*) - specimens 3; status common: observed foraging during day, abundant near dusk. No nests found.

Belted Kingfisher (*Ceryle alcyon*) - specimens 0; status uncommon: noted occasionally along shoreline in unburned areas.

Hairy Woodpecker (*Picoides villosus*) - specimens 1; status rare: seen in pine woods along airstrip south end of lake.

Northern Flicker (*Colaptes auratus*) - specimens 4; status common: individuals seen in both burned and

unburned areas. Pair and nest found west central shoreline near sandy area.

Olive-sided Flycatcher (*Contopus borealis*) - specimens 0; status common: heard and seen regularly singing from perches in Black Spruce bogs. Noted in southwest channel, northwest channel, tent site, and around the lodge.

Western Wood Pewee (*Contopus sordidulus*) - specimens 0; status uncommon: heard on two occasions singing in aspens north of lodge.

Alder Flycatcher (*Empidonax alnorum*) - specimens 1; status common: regularly heard singing in boggy areas along northwest and southwest channels.

Eastern Phoebe (*Sayornis phoebe*) - specimens 0; status uncommon: individual heard singing near camp.

Great-crested Flycatcher (*Myiarchus crinitus*) - specimens 0; status rare: one individual heard and seen coming from nest hole. Nest in dead snag in alder-willow thicket on west central shoreline.

Eastern Kingbird (*Tyrannus tyrannus*) - specimens 0; status uncommon: two birds heard and seen, one in the northwest channel and one in the southwest channel. No evidence of breeding found.

Tree Swallow (*Tachycineta bicolor*) - specimens 3; status common: pairs seen at both north and south ends of lake. Several pairs with nests in dead Aspen Poplars on east central shoreline.

Barn Swallow (*Hirundo rustica*) - specimens 1; status rare: individuals seen around camp and airstrip.

Gray Jay (*Perisoreus canadensis*) - specimens 3; status uncommon: one family group observed in small pines adjacent to airstrip.

Common Raven (*Corvus corax*) - specimens 0; status uncommon: occasional visitor at tent campsite, nest observed at south end of lake.

Boreal Chickadee (*Parus hudsonicus*) - specimens 1; status rare: one individual seen in heavy spruce forest on Wallace Island.

Red-breasted Nuthatch (*Sitta canadensis*) - specimens 0; status rare: one individual heard calling in mature spruce forest on Wallace Island.

Ruby-crowned Kinglet (*Regulus calendula*) - specimens 0; status uncommon: noted singing on several wooded islands, no evidence of breeding.

Swainson's Thrush (*Catharus ustulatus*) - specimens 2; status fairly common: not often seen but heard regularly around camp and on several wooded islands.

Hermit Thrush (*Catharus guttatus*) - specimens 0; status uncommon: heard occasionally around camp and along southwest channel.

American Robin (*Turdus migratorius*) - specimens 3; status fairly common: noted along airstrip, around camp and several pairs along sandy east central shoreline.

Bohemian Waxwing (*Bombycilla garrulus*) - specimens 1; status rare: several individuals noted in pines along airstrip.

Red-eyed Vireo (*Vireo olivaceus*) - specimens 3; status uncommon: three males heard and seen along west central shore. Area had been burned, now with very heavy alder and birch undergrowth.

Tennessee Warbler (*Vermivora peregrina*) - specimens 1; status fairly common: seen locally in mature aspens on west central shore. Rare in burned areas.

Yellow Warbler (*Dendroica petechia*) - specimens 4; status fairly common: seen or heard commonly in mature aspens and in alder willow thickets along southwest and northwest channels.

Yellow-rumped Warbler (*Dendroica coronata*) - specimens 15; status common: the most abundant warbler in area. Present in most habitats.

Palm Warbler (*Dendroica palmarum*) - specimens 2; status uncommon: noted on several occasions in Black Spruce along southwest channel. One individual in pines near airstrip.

Blackpoll Warbler (*Dendroica striata*) - specimens 0; status rare: heard and seen in alder-willow thicket

along the west central shore. Occasionally heard along southwest channel.

Northern Waterthrush (*Seiurus noveboracensis*) - specimens 0; status rare: an individual heard singing in thick willows along edge of southwest channel.

Chipping Sparrow (*Spizella passerina*) - specimens 9; status common: the most common sparrow in area. Seen or heard in all habitats surveyed.

Savannah Sparrow (*Passerculus sandwichensis*) - specimens 0; status rare: individual heard singing in boggy area at the north end of lake.

Fox Sparrow (*Passerella iliaca*) - specimens 1; status fairly common: heard and occasionally seen around camp, southwest channel, and in thick willow-alder growth along the west central lakeshore.

Song Sparrow (*Melospiza melodia*) - specimens 3; status fairly common: noted on most wooded islands. Occasionally heard or seen in shrubby willows along shoreline.

Lincoln's Sparrow (*Melospiza lincolnii*) - specimens 1; status fairly common: typical inhabitant of wet, marshy areas near camp and at both ends of lake.

Swamp Sparrow (*Melospiza georgiana*) - specimens 1; status fairly common: found in marshy areas with thick shrubby willows.

White-throated Sparrow (*Zonotrichia albicollis*) - specimens 1; status fairly common: regularly seen and heard in heavy deadfall.

White-crowned Sparrow (*Zonotrichia leucophrys*) - specimens 1; status fairly commmon: regular inhabitant of woody shrubbery and thickets. Rare on wooded islands.

Dark-eyed Junco (*Junco hyemalis*) - specimens 1; status uncommon: seldom seen but heard regularly in various habitats. Preferred tall pine or spruce singing perches.

Red-winged Blackbird (*Agelaius phoeniceus*) - specimens 6; egg sets 1; status fairly common: locally common in cattail marshy areas. Confirmed breeding in northwest channel cattails.

Rusty Blackbird (*Euphagus carolinus*) - specimens 0; status uncommon: one pair observed along southwest channel. Single birds noted in marsh along the northwest channel.

Common Grackle (*Quiscalus quiscula*) - specimens 0; status uncommon: occasionally observed flying overhead in marshy areas, south and north end of lake.

DISCUSSION

General

In the Andrew Lake area, we collected or confirmed a total of 66 species. In contrast, Wallis and Wershler (1984) reported 124 breeding or potentially breeding species in the Kazan upland of Alberta and Saskatchewan. A brief study of the Andrew Lake area by Höhn (see Appendix) revealed only 26 species and a survey of nearby Leland Lake (Höhn 1971, July 5-8, unpublished) included only 38 species.

A likely explanation for the low species diversity observed at Andrew Lake is the relatively harsh environment compared to areas adjacent to Lake Athabasca. Andrew Lake lies well within the Kazan Upland region of Alberta which seems to be a transition zone between the subarctic to the north and the boreal forest to the south and west. This region has lower annual precipitation, fewer frost free days, and a higher elevation than the region along the south shore of Lake Athabasca. Harper (1931) recognized this area as a distinct faunal region for which he proposed the name "Tazin Highlands." He suggested that the "fundamental distinguishing factor is a physiographic (or geological) one - the scantiness or absence of soil." This factor along with the environmental factors mentioned above result in a low tree species richness and reduced understory, which affects directly, or indirectly the numbers of species, occupying the region.

Harper (1931) lists 21 terrestrial species typical of the boreal forest that he did not find in the Tazin Highlands. Höhn (unpublished manuscript) suggests that climatic amelioration since the 1920s has increased the bird species diversity in the Tazin Highlands. Of the 21 species listed by Harper, Höhn noted 5 (Pileated Woodpecker (*Dryocopus pileatus*), Yellow-bellied Sapsucker (*Sphyrapicus varius*), Eastern Kingbird, Least Flycatcher (*Empidonax mini-*

mus), and Red-eyed Vireo in adjacent areas of northeastern Alberta. Our observations included five additional species (Sora, Killdeer, Palm Warbler, White-throated Sparrow and Red-winged Blackbird) from Harper's list.

If the Andrew Lake region fauna is characteristic of the Tazin Highlands then we support Harper (1931) in defining the Highlands as a distinct faunal region. Unfortunately, the extensive burn of 1979 is a secondary factor reducing forest cover and bird species diversity. With our data we cannot separate the effects of fire from those of environmental harshness.

Specific

Mew Gull: Three pairs were observed breeding at Andrew Lake. These are the second documented nesting records for Alberta. Wallis and Wershler (1983) documented the first breeding record for the province on Colin Lake.

Parasitic Jaeger: Five individuals were seen at Andrew but no evidence of breeding was or has been recorded for the province. This species seems to be a casual wanderer in the province.

Buteos and Owls: The absence of these two groups of birds likely is related to the low density of small mammals in the area (see Smith, this volume). The regeneration of the vegetation may lead to a recolonization by small mammals permitting some of these birds to return.

Sharp-shinned Hawk: The Sharp-shinned Hawk, Cooper's Hawk and American Kestrel were the only hawks or falcons observed. Their reliance on small birds and insects rather than mammals as prey accounts for their presence.

Bald Eagle: Wallis and Wershler (1984) reported that the Kazan Upland had the highest nesting density for Bald Eagles in the province. We observed two pairs with active nests and although a most conspicuous bird of prey in the area, were less numerous than observed at Bistcho Lake (McGillivray 1988).

Great-nested flycatcher: The first confirmed sighting in Alberta was in 1971 (Salt and Salt 1976). Subsequently regular sightings and breeding records have been made in east-central Alberta. Our observation constitutes the first record for the northern third of Alberta.

Red-eyed Vireo: The only vireo species observed in this area. The absence of Solitary Vireos goes largely unexplained, both Nero (1963) and Wallis and Wershler (1984) recorded this species in their respective studies. The absence of Warbling Vireos in this area mirrors the findings of Nero (1963), Höhn (1971) and Wallis and Wershler (1984).

Boreal Chickadee: Only one Boreal Chickadee was observed in the Andrew Lake area and no Black-capped Chickadees (*Parus atricapillus*) were noted. Given the distributions portrayed in Salt and Salt (1976) and Godfrey (1986), the absence of *atricapillus* is surprising. Gunn et al. (1975) and Höhn and Burns (1975, 1976) did not record *atricapillus* from Zama and the Caribou Mountains respectively. McGillivray (1988) noted the lack of Black-capped Chickadees in the Bistcho Lake region. Nero (1963) however, recorded the Black-capped Chikadee as fairly common in the Lake Athabasca region. Scotter et al. (1985) reports *atricapillus* as common in Nahanni National Park in the southwestern part of the Northwest Territories. There are obviously distributional gaps in the northern part of the range of *atricapillus*.

CONCLUSION

Sixty-six species of birds were recorded in 8 days of field work in the Andrew Lake area. This relatively low species diversity, as well as low density of birds is related to the harsh conditions, extensive burn and shallow soil of the area. The sparse vegetation produced by a lack of soil, high elevation, and low annual precipitation may be the ultimate limiting factors reducing species richness. A follow up study in ten or fifteen years would be useful to assess the significance of the burn.

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Appendix. Birds seen at Andrew Lake, northeastern Alberta, 10-14 July 1970
(E.O. Höhn accompanied by Michael Smith).

* beside trivial name indicates species for which proof of breeding was obtained.

***Common Loon:** about one pair per mile of lakeshore, one pair with two downy young, July 11.

***Mallard:** locally scarce, a female with downy young, July 11. Another female with young, July 12.

Common Merganser: a male seen July 10, two females July 14, probably breeds about the lake.

Goshawk: July 12 a male perched in a tree for a few seconds only, on the lakeshore near our camp.

Bald Eagle: seen daily, near our camp on the midwest shore there was a pair and an immature, another pair near the northern end of the lake behaved as if they had a nest nearby. July 12 an adult flushed from a lakeshore nest in a conifer but I am 90% sure the nest held no youngsters.

***Spruce Grouse:** a female with young, all already able to fly, per two m of lakeshore followed. Only one male seen. Females with young seen daily.

***Spotted Sandpiper:** Nest with four eggs on lakeshore, July 11.

Solitary Sandpiper: one on shore near camp July 11 and 12.

Yellow Legs (? species): calls heard near camp evening of July 11 and 13.

Ringed-billed Gull: a few seen daily on or about rocky islets near camp, no indication they were nesting locally.

Common Tern: a few seen July 11.

Night Hawk: several seen over camp every evening.

Belted Kingfisher: one by our camp July 10, one about fives miles further north on the lakeshore July 11. Another species Harper says is absent.

Yellow-shafted Flicker: call heard on several days, bird seen July 14.

Olive-sided Flycatcher: call heard July 14.

Tree Swallow: glimpse of one over the lake July 12.

Gray Jay: a few seen daily.

Raven: pair seen near camp daily.

Boreal Chickadee: two seen July 13.

Swainson's Thrush: a few seen daily, still in song.

Ruby-crowned Kinglet: songs of at least two different ones heard July 14.

Red-eyed Vireo: several in song and at least one very well seen. Almost certainly breeds locally in spite of Harper's claim of its absence in the area.

Tennessee Warbler: one well seen July 11.

Myrtle Warbler: one well seen July 11, also a family party near camp July 13.

Red-winged Blackbird: several at the northern end of the lake where there is a little marshy ground July 11.

***Chipping Sparrow:** seen daily, still in song, nest with three eggs, July 11.

Lincoln's Sparrow: one seen July 13 on a small lake abut one mile west of Andrew Lake

MAMMALS AT ANDREW LAKE, ALBERTA

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Along with other natural history programs, the mammalogy section of the Provincial Museum of Alberta took part in a biological survey of the Andrew Lake area in the Kazan uplands of northeastern Alberta (Fig. 1). For a description of the area see Hastings and Ellis (this volume). The field program ran from 10 to 19 June 1988. Although numerous mammal surveys have been made in northeastern Alberta (Richardson 1829, Preble 1908, Soper 1942) only one, Wallis and Wershler (1984), was in the Kazan uplands and none has been undertaken in the Andrew Lake area. Höhn visited Andrew Lake in 1970 and made brief mention of the mammals observed there but he did not publish the results of his work.

Richardson (1829) and Preble (1908) conducted mammal surveys at Fort Chipewyan in the Lake Athabasca area and along the Slave River to Fort Smith. Their work was confined to the Slave River lowlands. Richardson (1829) did not identify his collecting sites and it is not possible to determine the species he collected in this area. Preble (1908) discussed 81 species in his paper, 19 species are from the area between Fort Chipewyan and Fort Smith. Soper (1942) spent two years, 1932 to 1934, studying mammals in Wood Buffalo National Park. He recorded 36 species during his surveys.

In the period 1974-75, 44 registered trap lines were located in the Fitzgerald Map Sheet (74M) area (Boyd and Todd 1977), which includes Andrew Lake. Using affidavits from fur trappers who operated trap lines in this area, Boyd (1977) reported 13 species of fur-bearers.

Wallis and Wershler (1984) did a brief survey of mammals in the Wylie and Colin Lake areas (approximately 50 km and 25 km respectively south of Andrew Lake). They did not conduct a trapping program but made observations and recorded evidence of mammals on their study sites. They saw or had evidence of eight species in the area, and on the basis of literature references, included 10 more species.

METHODS

From the base camp on the southwest shore of Andrew Lake, Museum special traps were set in lines in a number of habitats. The number of traps set per trapping period ranged from 120 to 180 in strings of 40 to 50 traps. Lines were left in place for two or three nights and were checked periodically throughout each day. The trapping period extended from 12 June to 18 June. Besides trapping, mammals were collected by shotgun or rifle. All specimens collected were frozen for later preparation or were skinned and fleshed out on-site. All specimens are housed in the mammal collection of the Provincial Museum of Alberta.

In the Species Account section the following terms are used with reference to the status of a species:

Common: A species is considered common if it was collected more than once and/or it was observed on a regular basis.

Uncommon: A species is considered uncommon if a specimen was collected but it was not seen regularly although the habitat was available for it to be there.

Not determined: Although a specimen was obtained, the circumstances were such that it was not possible to assess the abundance of the species.

RESULTS AND SPECIES ACCOUNT

We collected 23 specimens of nine species in the Andrew Lake area. Three specimens (2 species) were secured on the trap lines, 15 specimens (3 species) were shot, and five skeletal elements (4 species) were picked up in the study area. On the basis of previous mammal studies in northeastern

Figure 1. Location of the study area – Andrew Lake, Alberta.

Alberta it was anticipated that we would collect or find evidence of approximately 28 species in the Andrew Lake area.

Snowshoe Hare (*Lepus americanus*)
Specimens Collected: 4 (3 adult females, 1 immature male)

Status: uncommon

Although four specimens were collected at Andrew Lake, this species is considered uncommon because it was seen only occasionally. The females, each pregnant and each with three embryos, were collected in a Jack Pine (*Pinus banksiana*)-Paper Birch (*Betula papyrifera*)-Trembling Aspen (*Populus tremuloides*) stand where there was also considerable deadfall. The male, an immature, was collected in a stand of Black Spruce (*Picea mariana*) and Paper Birch that had a ground cover of moss.

Höhn did not mention this species when he visited Andrew Lake. Wallis and Wershler (1984) found Snowshoe Hares in essentially the same habitat at Colin and Wylie Lakes and also considered the species uncommon.

Red Squirrel (*Tamiasciurus hudsonicus*)
Specimens collected: 7 (3 adult females, 4 adult males)

Status: common

Red Squirrels were collected in stands of Black Spruce and they were seen in other habitats as well. Two of the females were lactating and each had 5 placental scars. One female was non-parous. All males had scrotal testes that ranged in size from 14 mm x 8 mm to 18 mm x 11 mm.

Beaver (*Castor canadensis*)
Specimens collected: 4 (1 adult female, 1 adult male, 2 immature females)

Status: uncommon

The specimens we collected were the only Beavers observed in the area. Höhn saw "many recent signs and at least one lodge."

Deer Mouse (*Peromyscus maniculatus*)
Specimens collected: 2 (2 adult males)

Status: uncommon

The two specimens were caught several days apart on the same trapline in a re-generating Jack Pine-Paper Birch-Trembling Aspen stand. In 1970, Höhn trapped one near his camp site on Andrew Lake.

In their survey of Wylie and Colin Lakes, Wallis and Wershler (1984) did not run traplines for small mammals. As a result they did not encounter this species. They included the species on their list of species for their study areas on the basis of reports from Saskatchewan in Harper (1932).

Southern Red-backed Vole (*Clethrionomys gapperi*)
Specimens Collected: 1 (1 adult female)

Status: uncommon

This species was taken on a trapline in a Black Spruce, Paper Birch stand. The specimen, an adult female, was not pregnant but showed five placental scars.

Wallis and Wershler (1984) included this species in their report but they did not see it at either Wylie Lake or Colin Lake. They included the species on the basis of Harper's (1932) work in Saskatchewan.

Gray Wolf (*Canis lupus*)
Specimens Collected: 1 (1 lower jaw)

Status: not determined

Wolves no doubt occur regularly in the Andrew Lake area but during our survey no tracks were observed and no one reported signs that could be interpreted as belonging to wolves. Wallis and Wershler (1984) saw tracks and heard wolves howling during their study at Colin Lake.

Red Fox (*Vulpes vulpes*)
Specimens Collected: 1 (1 skull)

Status: not determined

The skull reported here was picked up on Wallace Island. There was no other evidence of Red Fox occurring in the area. In the period 1970-75, 27% of the trappers in the area covered by Map Sheet 74M reported taking Red Fox (Boyd 1977).

Marten (*Martes americana*)
Specimens Collected: 1 (1 partial skull)

Status: not determined

Marten are scarce in northeastern Alberta; only 1% of the trappers in the Map Sheet 74M area reported this species (Boyd 1977). This skull provides evidence of the occurrence of this species in the area.

Caribou (*Rangifer tarandus*)
Specimens Collected: 2 (1 partial skull and 1 antler)

Status: not determined

We salvaged our specimens from a garbage site in the vicinity of a fishing lodge on the western shore of Andrew Lake. From the description in Banfield (1961) these specimens are referred to the group "cylindricornis," that is, those Caribou that have long, cylindrical antlers. Included in this group is the Barren-ground Caribou (*Rangifer tarandus groenlandicus*). Höhn reported seeing a number of cast antlers on the western shore of Andrew Lake and he believed they were of the Barren-ground form. He also saw fresh tracks near his campsite and believed them to be of the Woodland Caribou form (*Rangifer tarandus caribou*).

Wallis and Wershler (1984) reported seeing cast antlers in the Wylie and Colin Lake areas and referred them to the Barren-ground form.

DISCUSSION

The low number of small mammals (shrews, mice, voles) obtained was surprising. One possible explanation for the low numbers was that the trapping program was neither long enough nor sufficiently intensive. This argument does not seem reasonable when a similar trapping program was employed at Bistcho Lake in 1987 (Smith 1988) with good success. A better explanation is that the small mammal population in the Kazan upland generally and Andrew Lake specifically is always low. For example, an examination of the bird observations at Andrew Lake shows a scarcity of such mammal-eating birds as owls and buteo hawks (Erickson and McGillivray this volume). Wallis and Wershler (1984) reported seeing only one owl [Northern Hawk-Owl (*Surnia ulula*)] at Wylie Lake. Also Wallis and Wershler (1984) did not observe any small mammals in their studies and Höhn was able to trap only one Deer Mouse.

If the numbers of small mammals in the Kazan uplands is always low, the effects of forest fires may be more devastating to the population than if the numbers are high. Buech et al. (1977) have shown that small mammals can survive wild fires by burrowing into the soil layer or retreating to unburned areas. At Andrew Lake the soil layer is extremely shallow and could not provide sufficient protection to any individuals that were burrowed into it during the fire in 1979. This fire was so severe that there were no unburned areas to which a resident population could retreat (for details on the 1979 fire at Andrew Lake see Hastings and Ellis this volume). Because of these factors - low initial population, lack of soil for burrowing, and lack of refuge areas - the small mammal population was probably destroyed. The only way the Andrew Lake area can be re-populated is by immigration. As Andrew Lake is located within the centre of an extremely large area that was destroyed by fire, small mammals that could be potential settlers have to travel great distances. The possibility is that there has not been sufficient time since the fire to allow many immigrants to occupy the area. As well, those individuals that have immigrated may have found the area to be so poor that their reproductive success was low.

In studies of post-forest fire sites the Deer Mouse population is highest and the Red-backed Vole population is lowest within the first few years post-fire (Ahlgren 1966, Beck and Vogl 1972, Krefting and Ahlgren 1974). Deer Mice are favored because there is less forest litter, and as Deer Mice are consumers of seeds, there is a larger source of food available from rapidly growing, seed producing plants. Red-backed Voles prefer a forest floor with litter and a diet of plant stems and leaves, hence their numbers are low in the first years after a fire. As a fire site ages, litter accumulates and the composition of plants changes, there is a reversal in populations of Deer Mice and Red-backed Voles. Whether this is the situation at Andrew Lake is not clear at this time. The area is re-generating and the litter layer is sparse but a ratio of 2 Deer Mice to 1 Red-backed Vole is not sufficient to indicate a population trend.

CONCLUSION

Twenty-three specimens of 9 species were collected between 10-19 June 1988 at Andrew Lake in northeastern Alberta. The paucity of small mammals in the area is likely from a combination of a normally depauperate fauna further decimated by a severe forest fire. Studies of colonization over time by small mammals would be quite productive.

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